

Weathering the Future

The climate has always been changing.

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**Joint HUG and NHA
Central/Midwest Regional Meeting**

May 8, 2008 • Wausau WI

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Many Solutions®





John F. Henz: "my roots"

- BS, Meteorology, U. Wisc.
 - 4 yrs in Air Weather Service
 - MS, Atmospheric Science, Colorado State Uni.
 - CCM #270
-
- GRD Weather Center (1972 – 1982)
 - Henz Kelly & Associates (HKA, 1983-1989)
 - Henz Meteorological Services (HMS, 1990-2000)
- HDR Engineering, Inc of Omaha NE purchased HMS Nov 2000.
 - Nat. Tech Advisor, Hydro-Meteorology - HDR
 - Atmospheric Science Group Leader - HDR
 - Board of CCM (AMS)
 - Board of Economic Enterprise Development (BEED) AMS



Wisconsin "Badger" years (9/1963 – 12/1967)



Unrest, riots, gas and rebellion



If your combined GPA fell below 3.0",
You were drafted and sent to Vietnam



Wisconsin "Badger" years (1963 – 1968)

"you'll never become a meteorologist unless"



Professor Reid Bryson, circa 1984

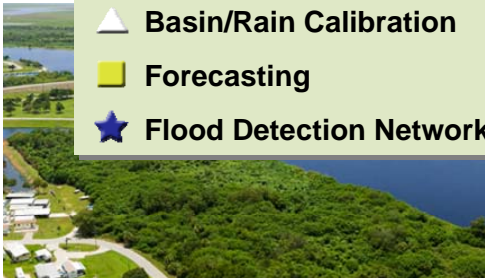
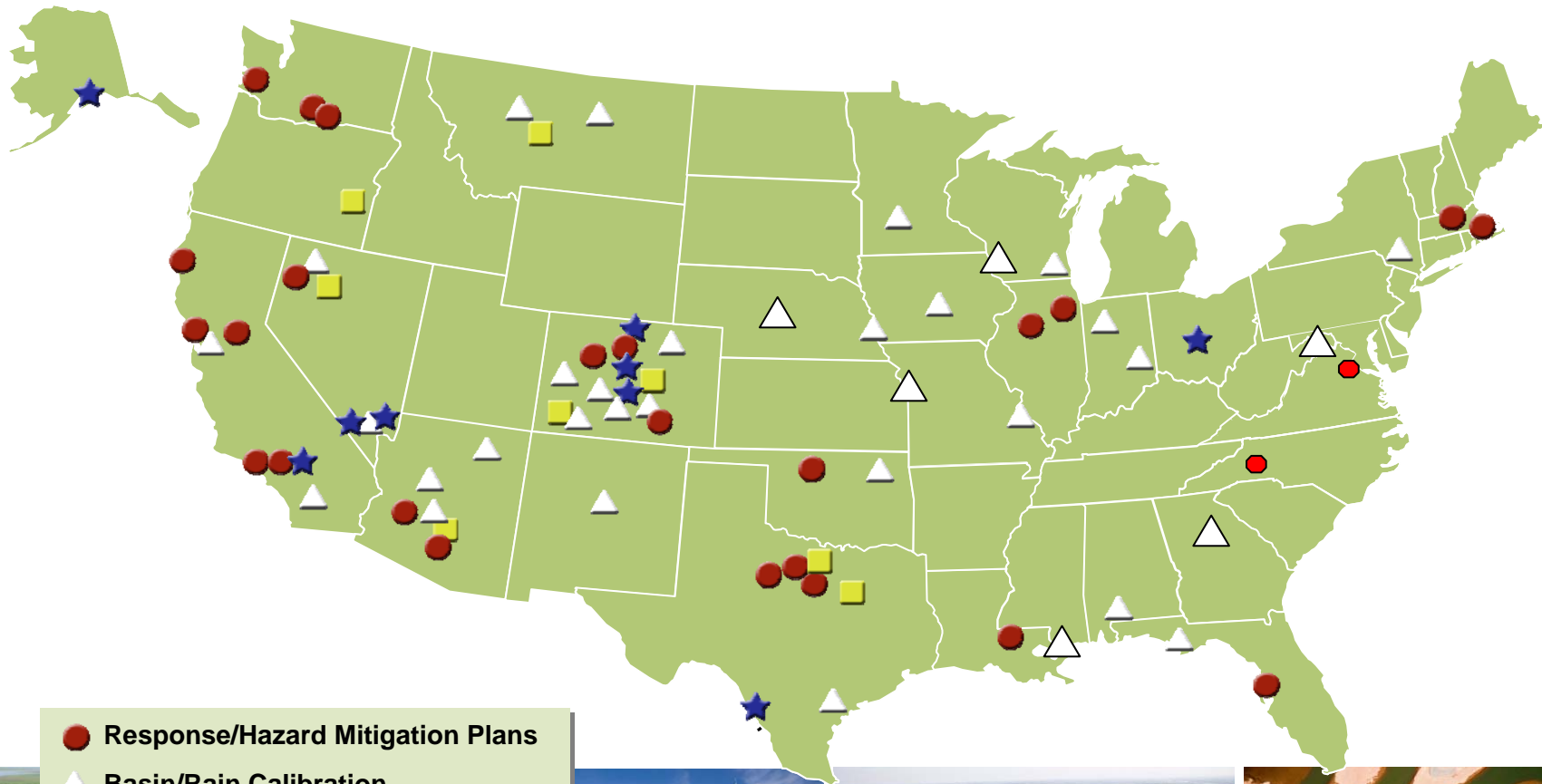
"think great thoughts then do them"



Yes, I closed Wolski's when I turned 21!



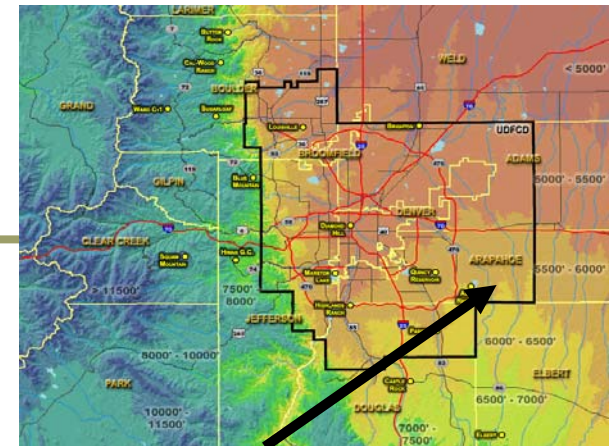
HDR ASG projects 2000-2008



“Perception is everything: an example”



January 1, 2007: 57.8"/ 7 days



Oct – May 1
snowfall

SE Aurora (HEB)
5995 feet elevation

159.1 inches
(17.26" liquid)

Average snow: 92"



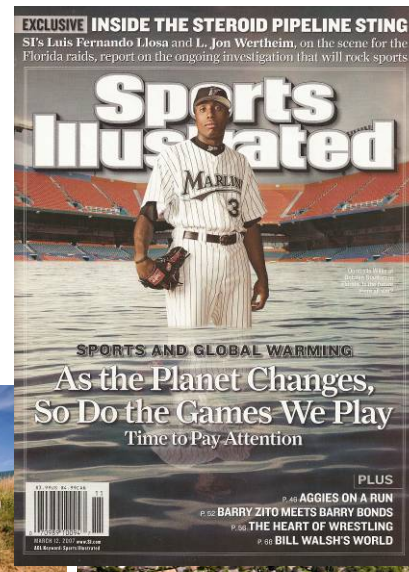
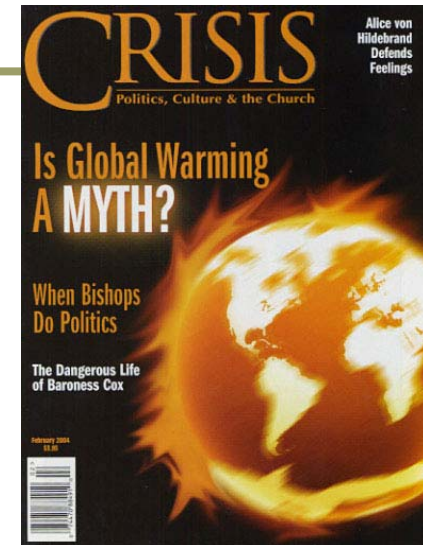
My neighbor across the street had other ideas!



"Perception is everything: more examples"



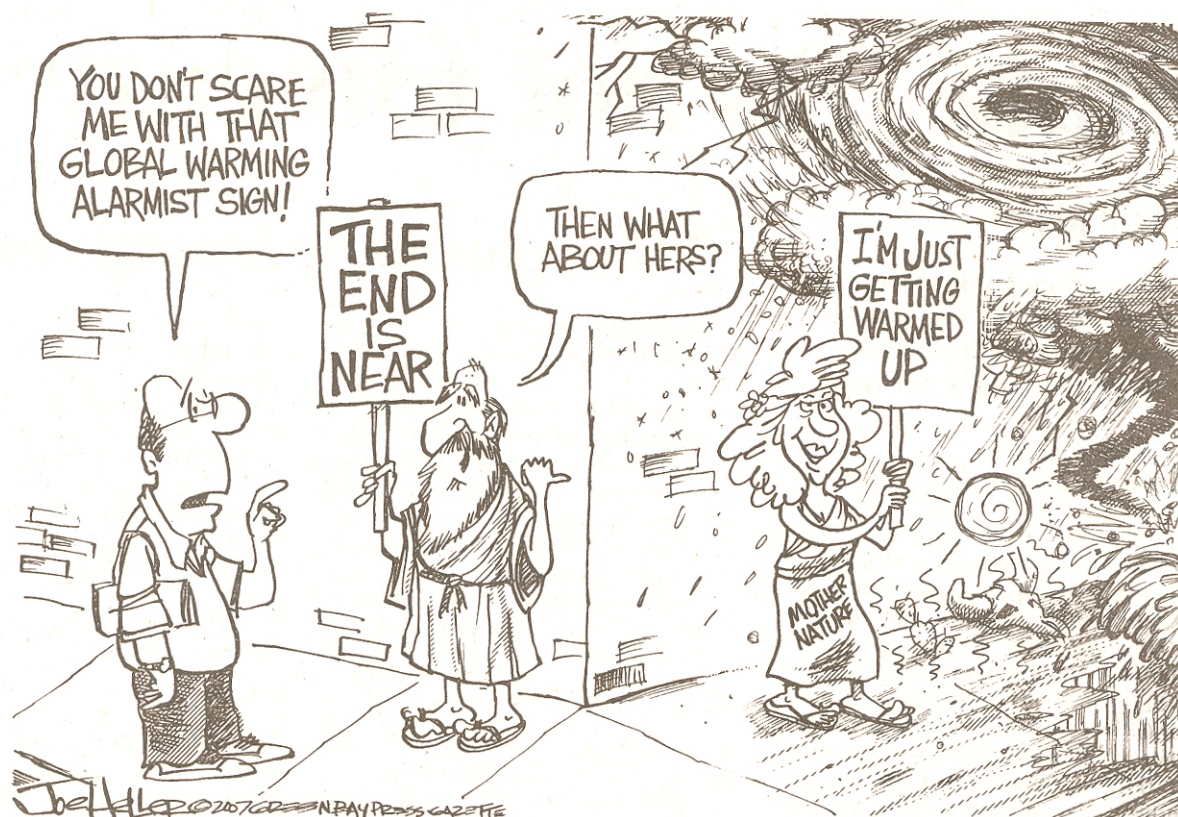
Climate Change in the News



Asking questions is good.

OPINION

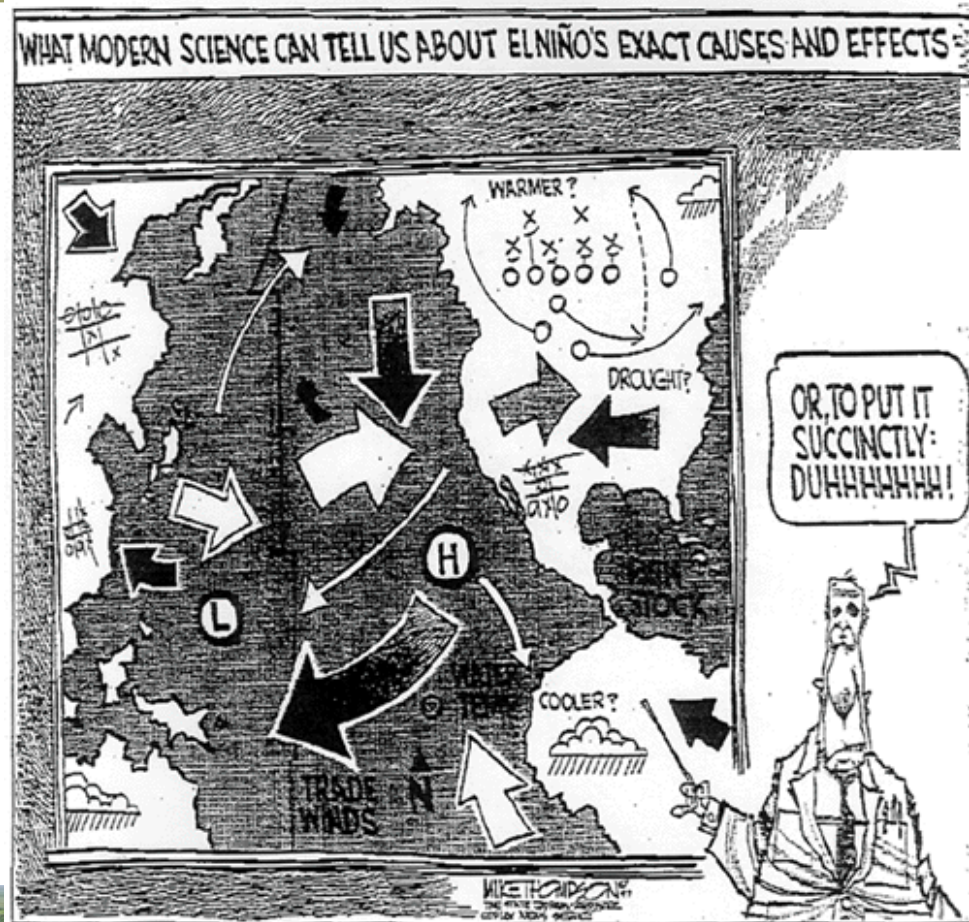
TUESDAY, JUNE 19, 2007



Joe Heller | Green Bay Press-Gazette



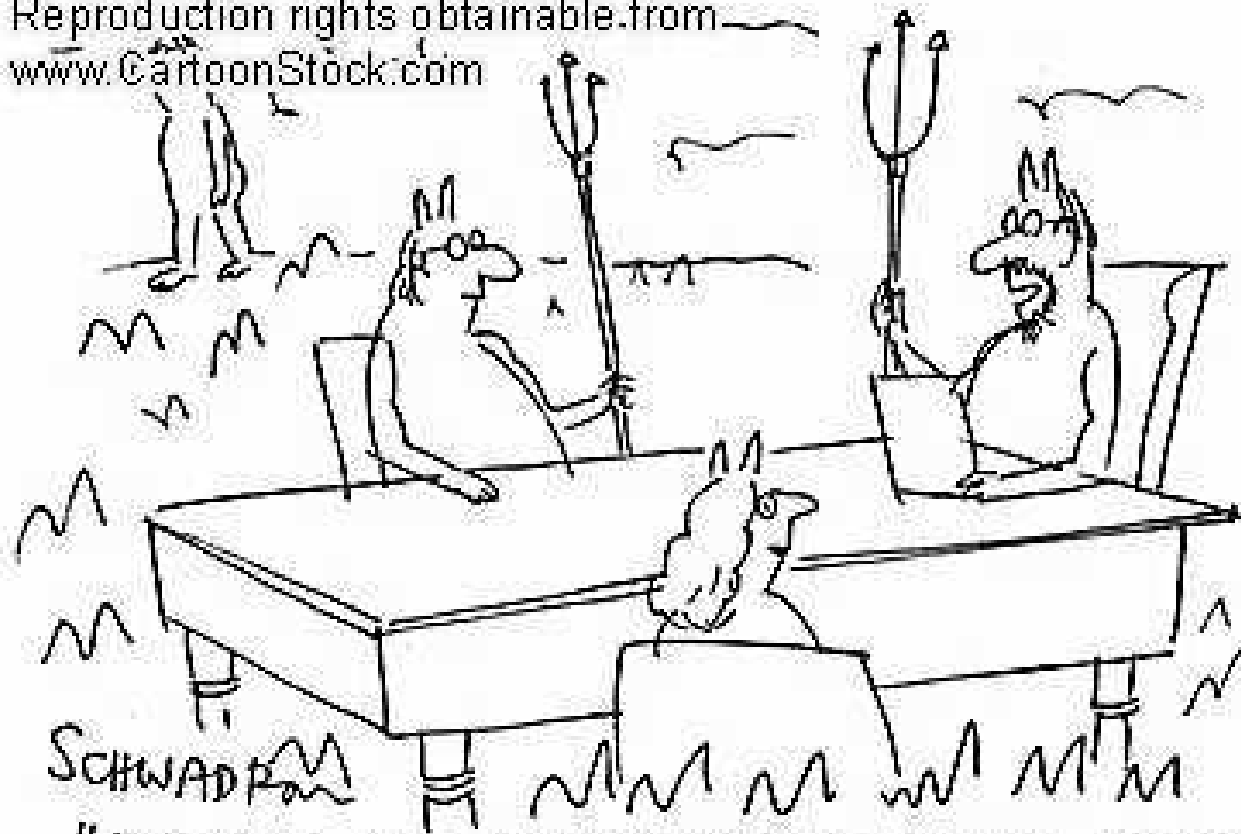
Science can appear confusing to some



There's always an optimist in the crowd

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SCHWADRON

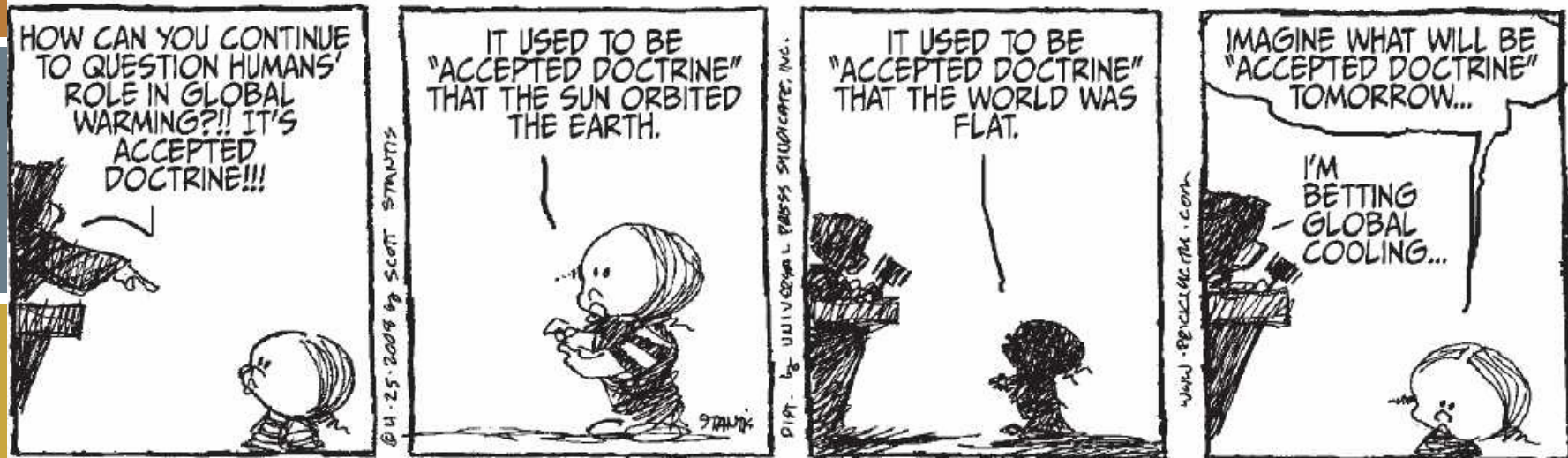
"THE GOOD NEWS IS: ANY CHANCE OF HELL FREEZING OVER HAS BEEN MINIMIZED BY GLOBAL WARMING."



A final parting thought

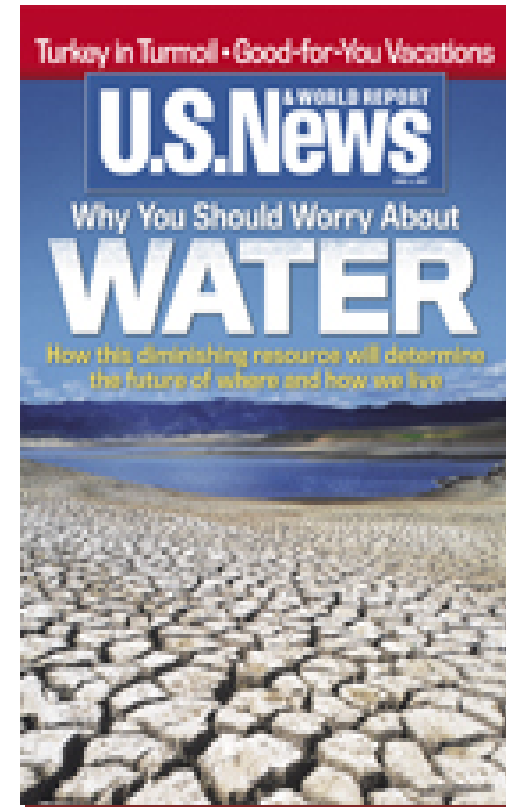
PRICKLY CITY

Scott Stantis

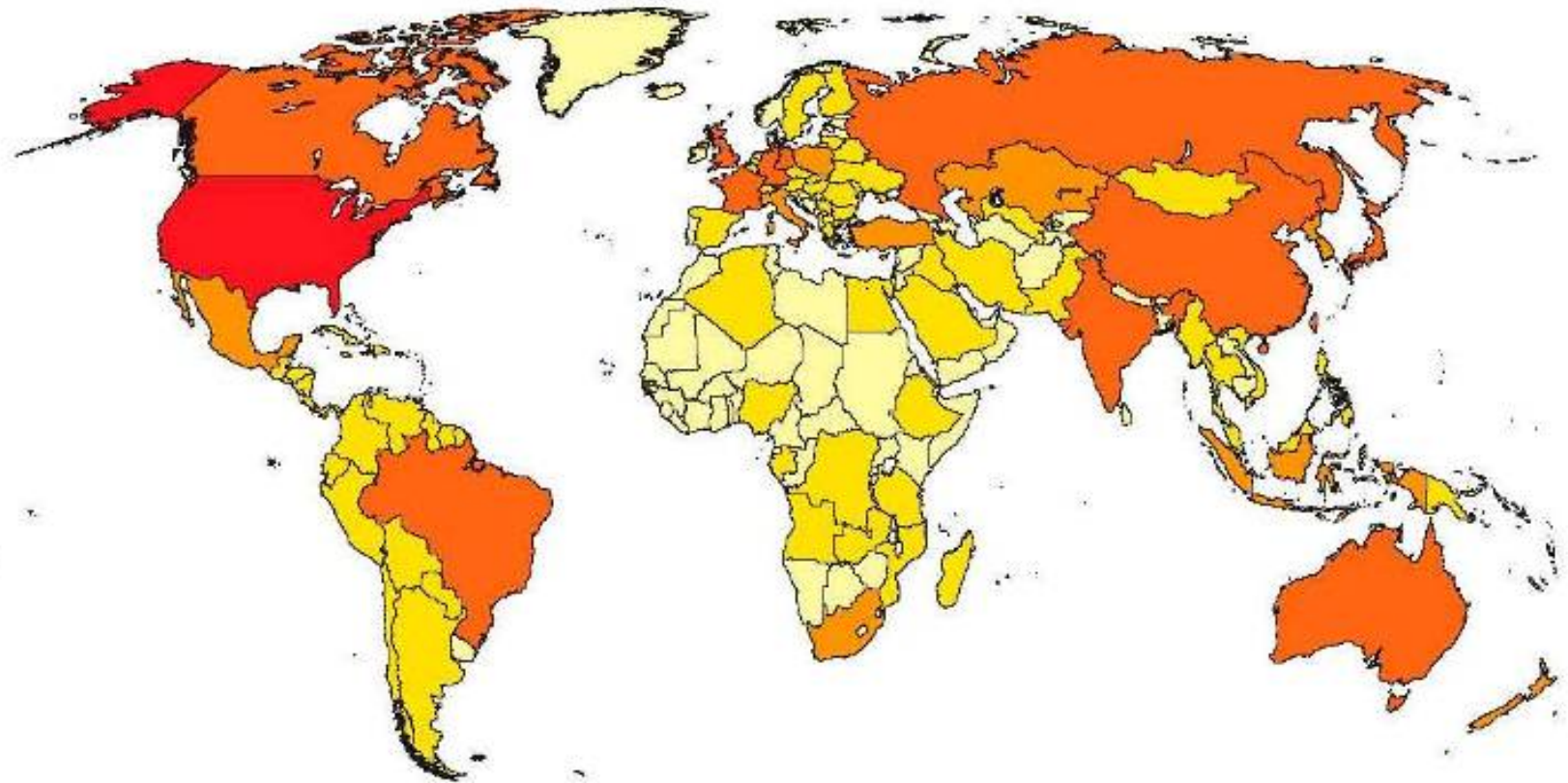


The Water Challenge

- Supply: Climate change is a wild card in resource forecast
- Climate variability, whether short or long term, has significant implications to water management.
- The question is how much and when?



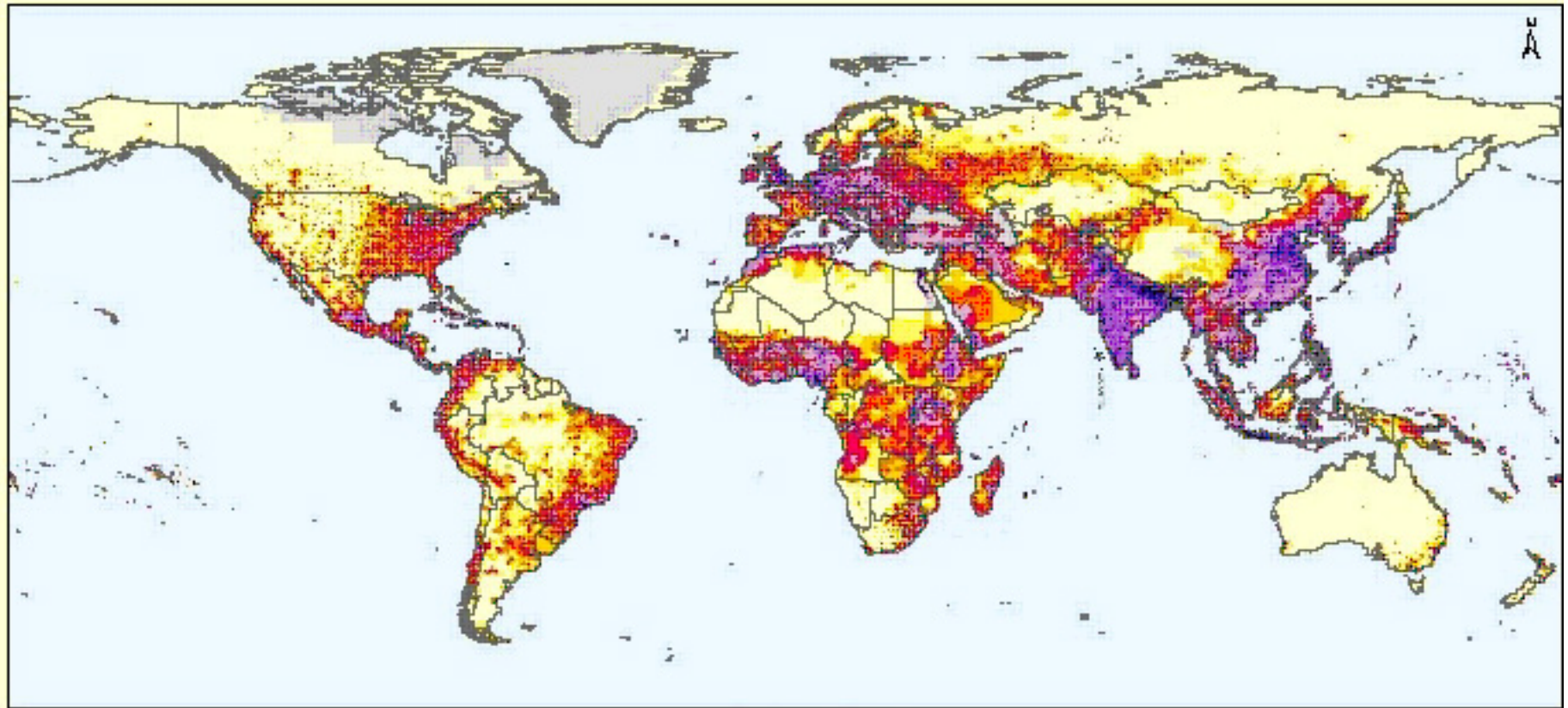
The Global Challenge



CO₂ emissions from fossil fuel combustion and cement production, including land use change (MtC per year from 1950 - 2003)



World population density challenge

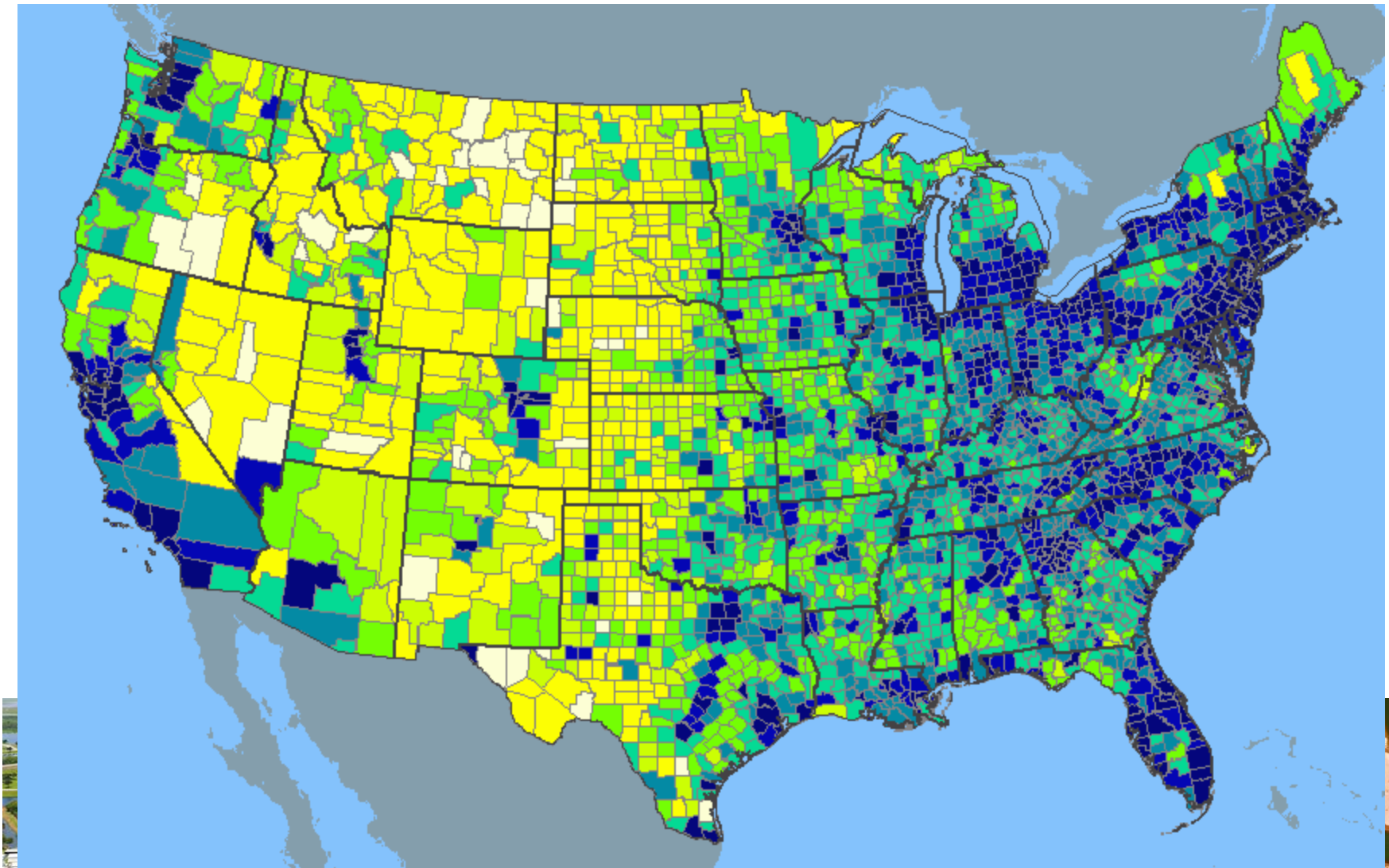


Geographic Projection (Lat/Long)

Persons per Km²

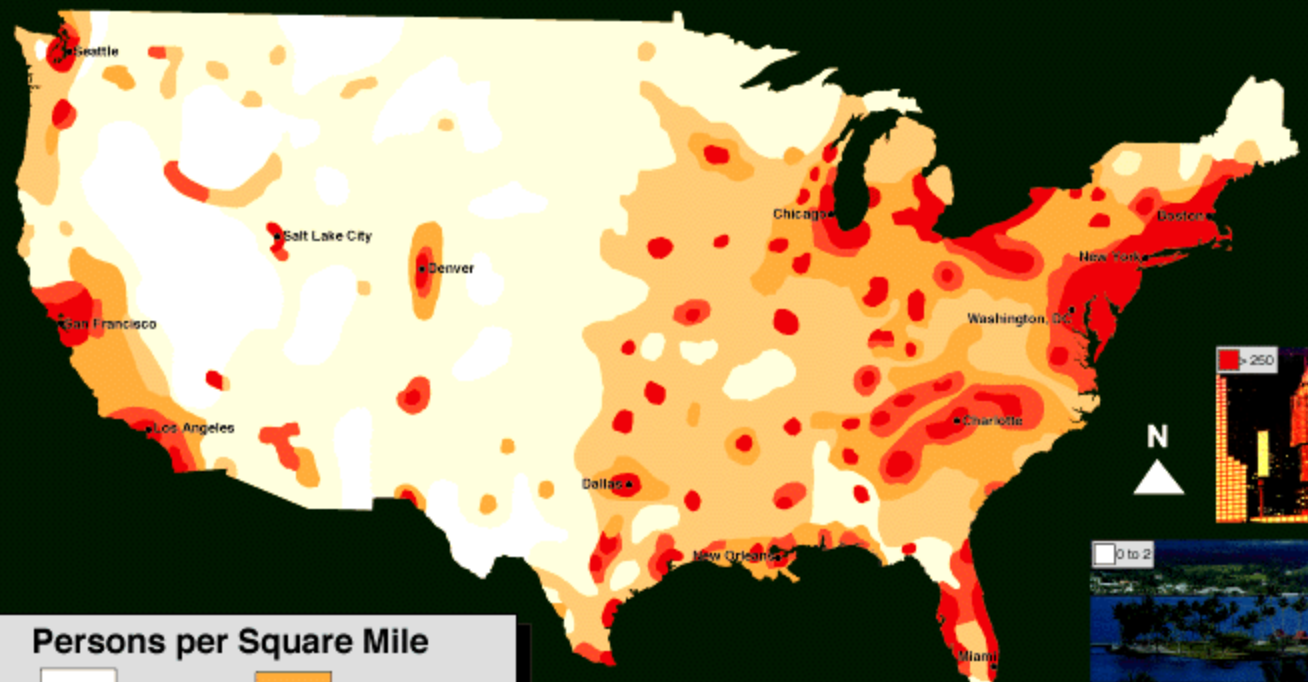


US population density



People per square mile

Population Density of the United States

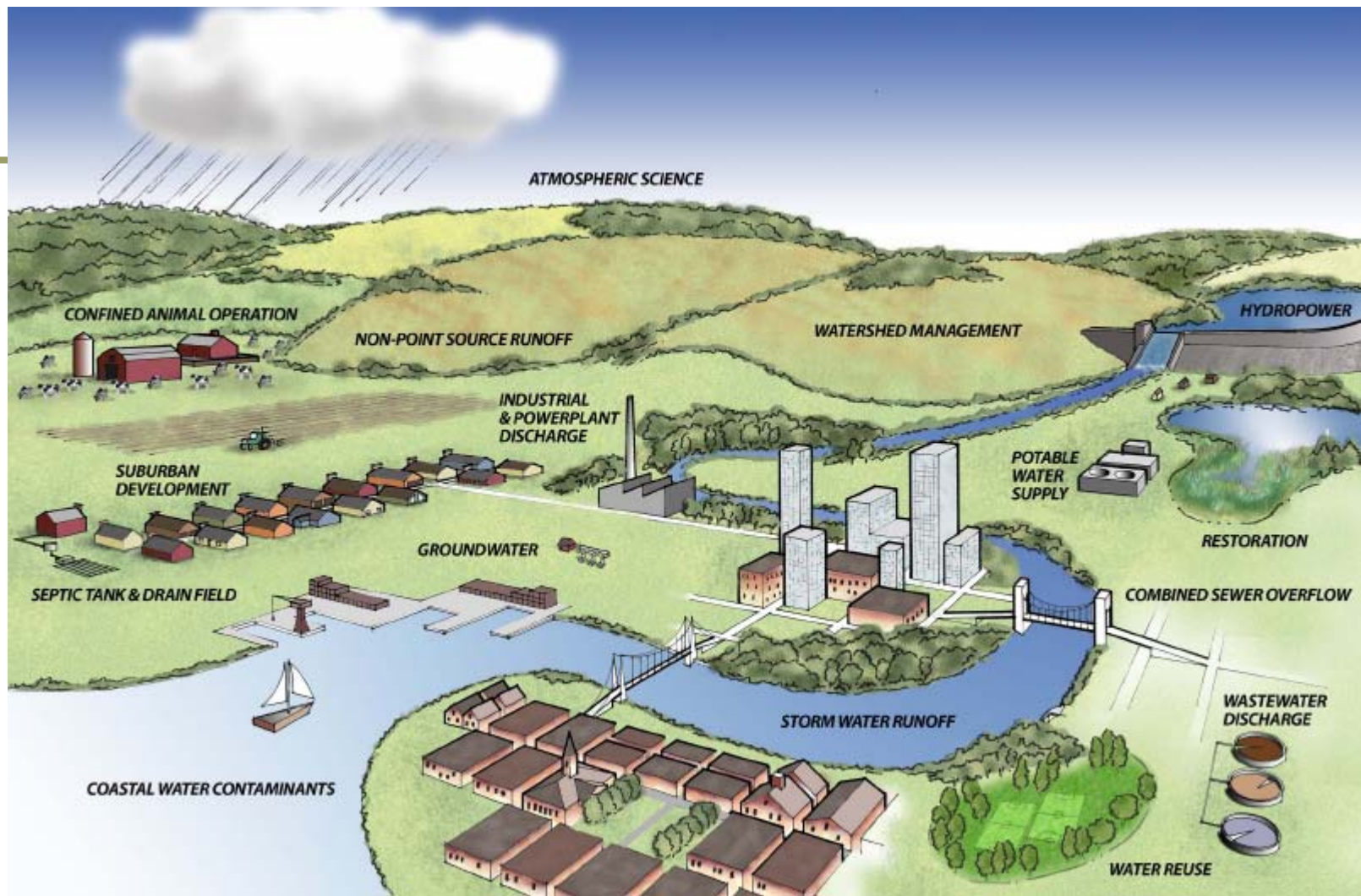


Persons per Square Mile

0 to 2	65 to 130
2 to 25	130 to 250
25 to 65	Over 250

0 200 400 600
Miles

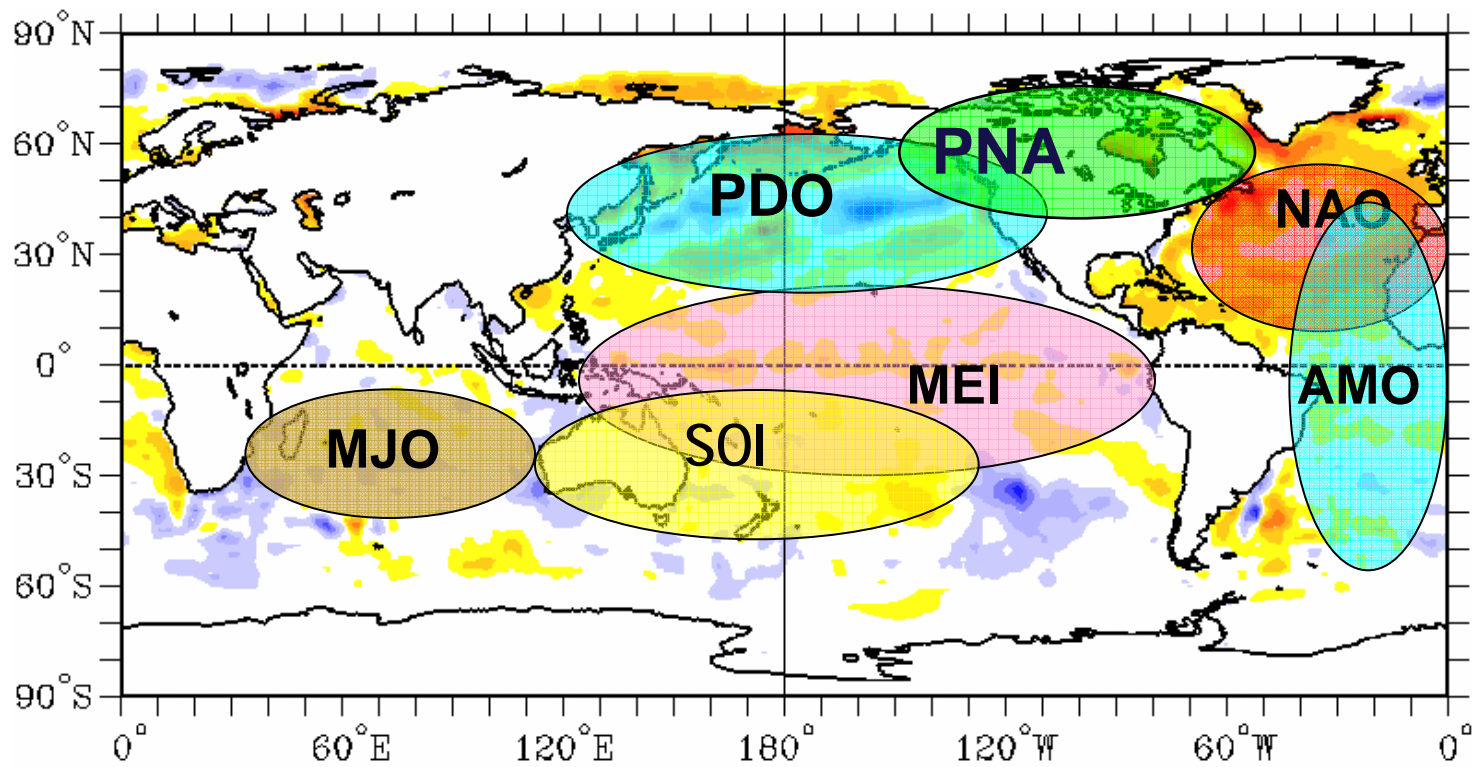
Source: *The Nystrom Desk Atlas*.
Cartography By: Cameron Gardner
UNC-Charlotte Cartography Lab



Let's look at the use of one tool:
hydro-climate indices.

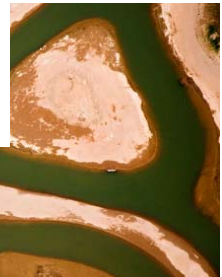
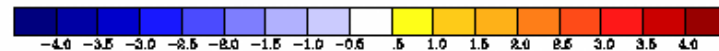


Crucial climate information for strategic decision-making: hydro-climate indices

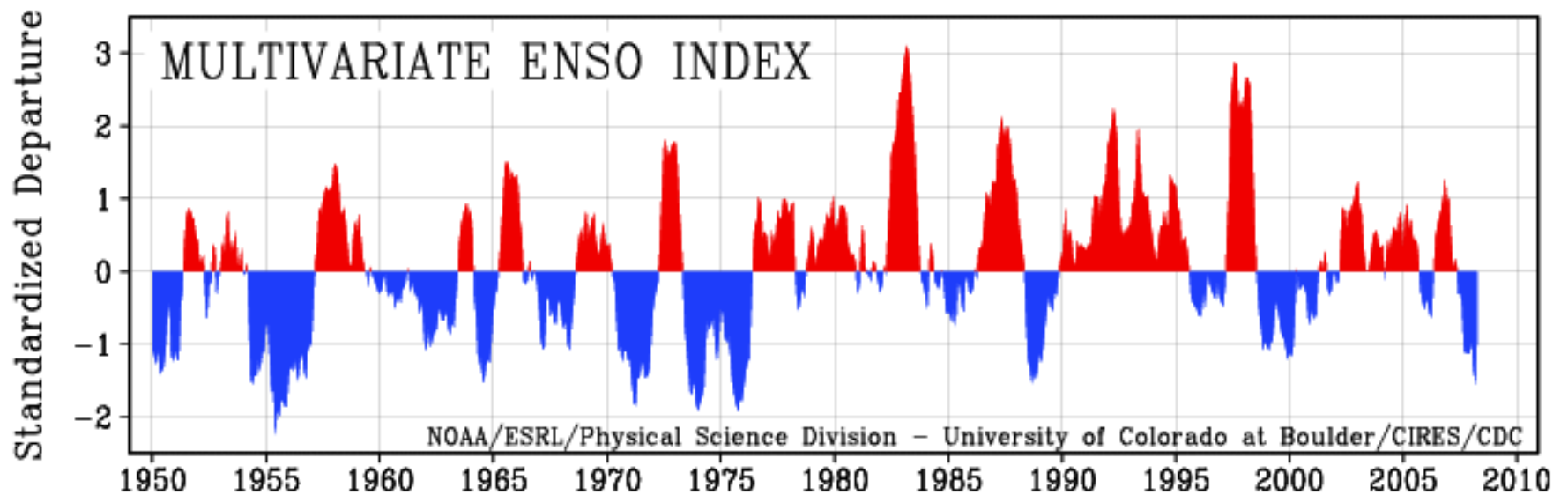


SST ANOM 10/12/03-10/18/03

Base Period: 1982-96



Over 50 years of El Nino and La Nina

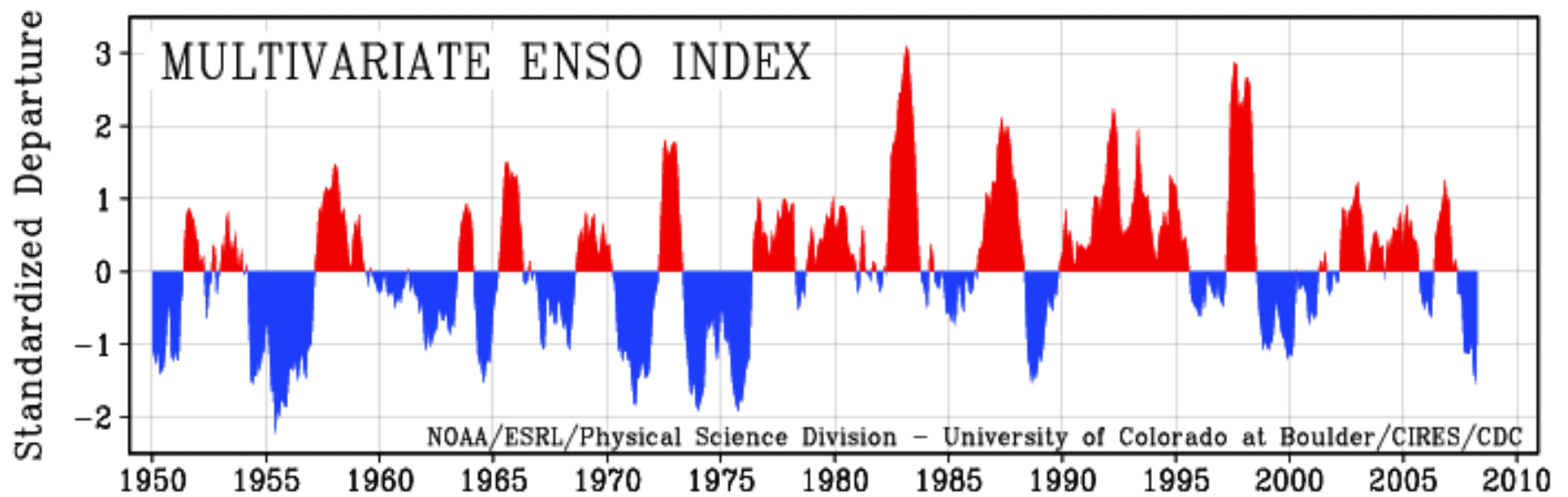


Blue lines are La Nina

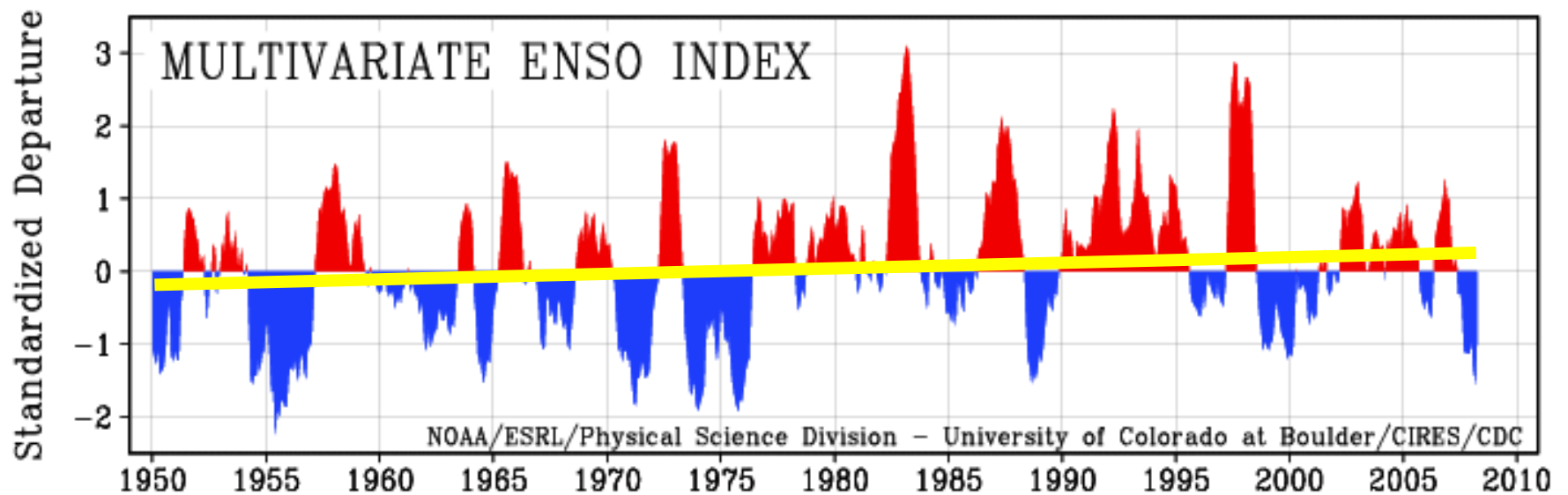
Red lines are El Nino



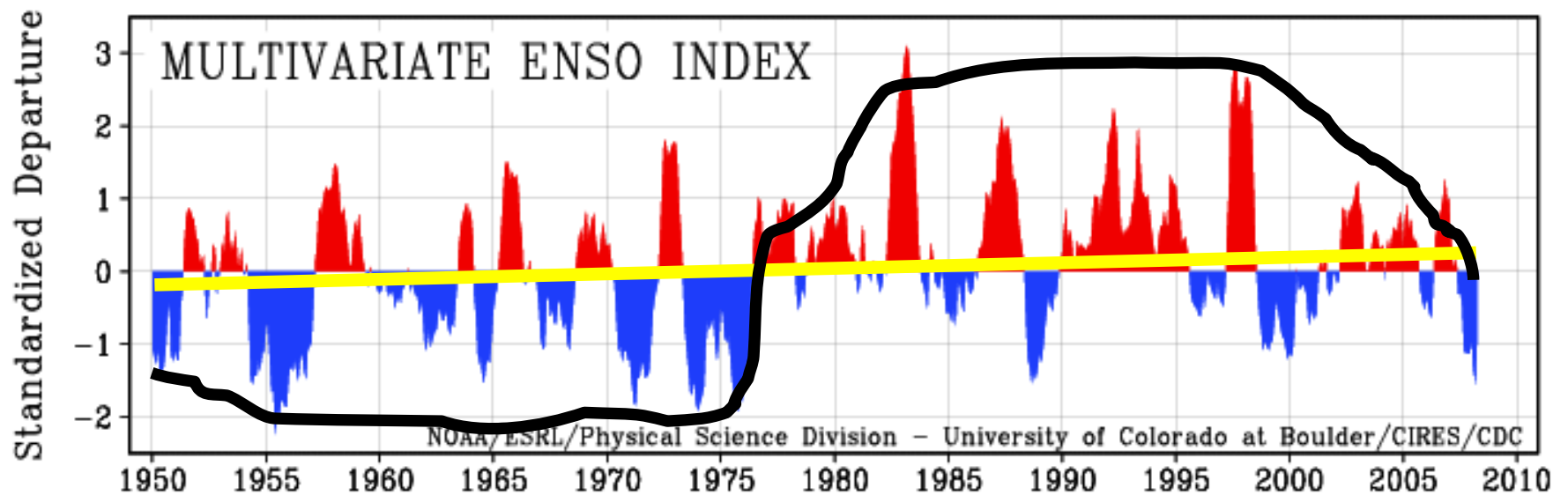
Is there a trend?



Is there a trend? An increase of + 0.18 in 58yrs

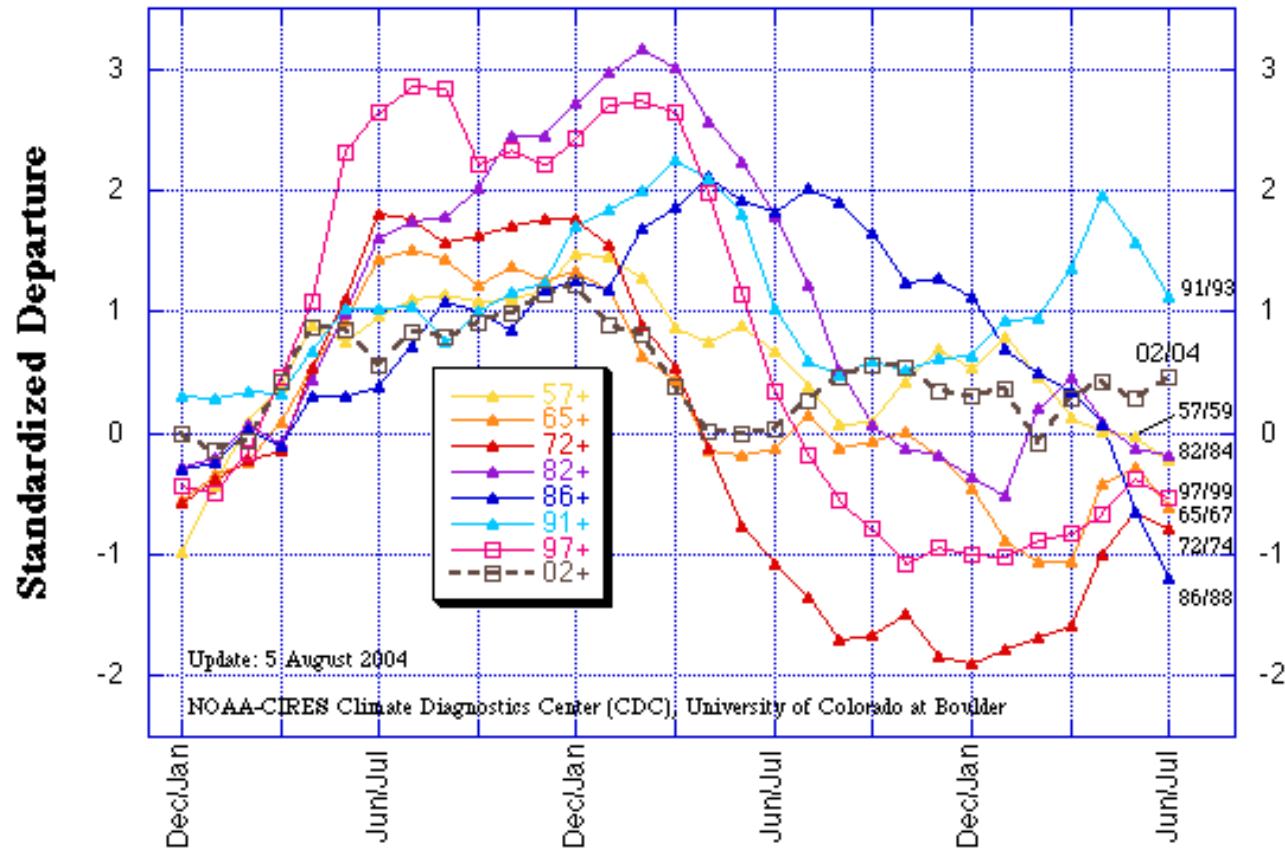


Is there also a trend of another kind?



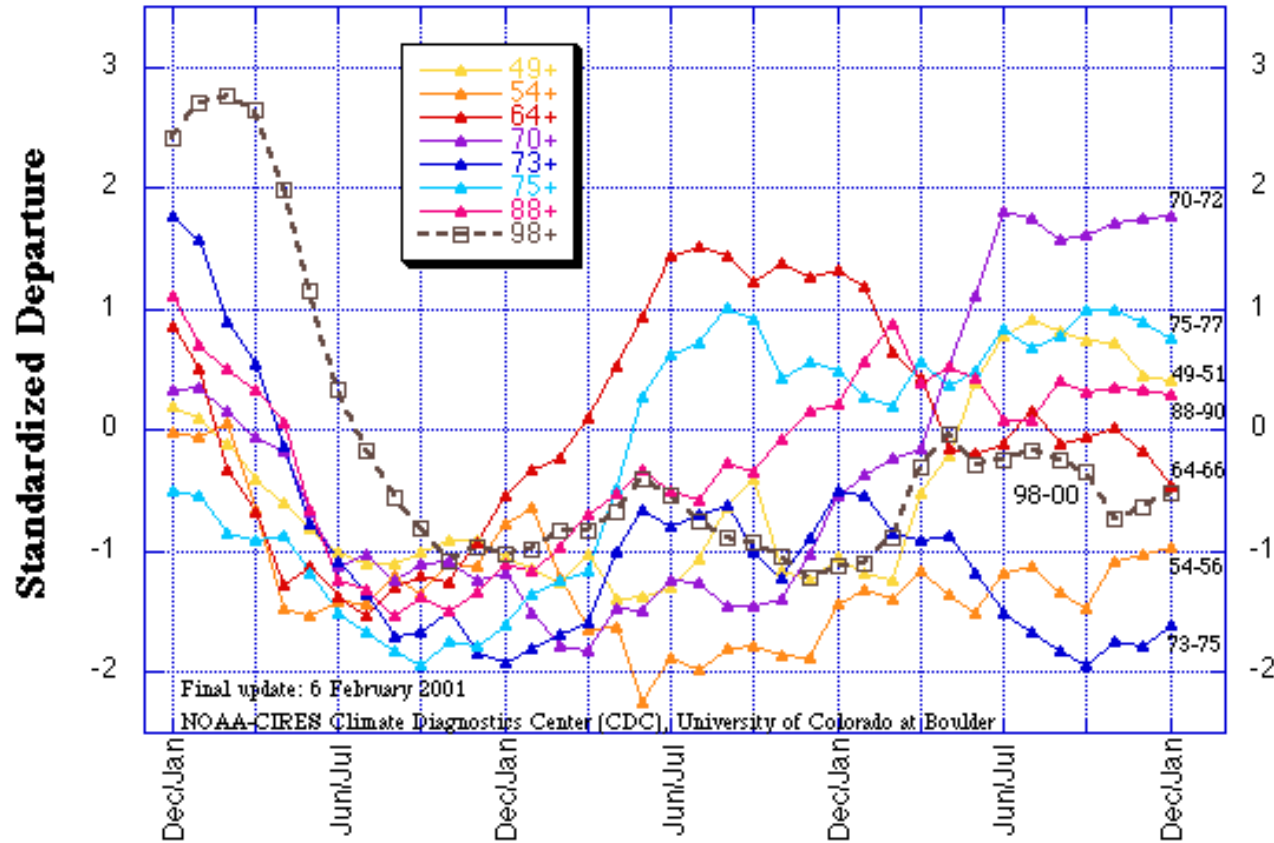
El Nino's are not all equal

**Multivariate ENSO Index for the 7 strongest
El Niño events since 1950 vs. 2002-04**

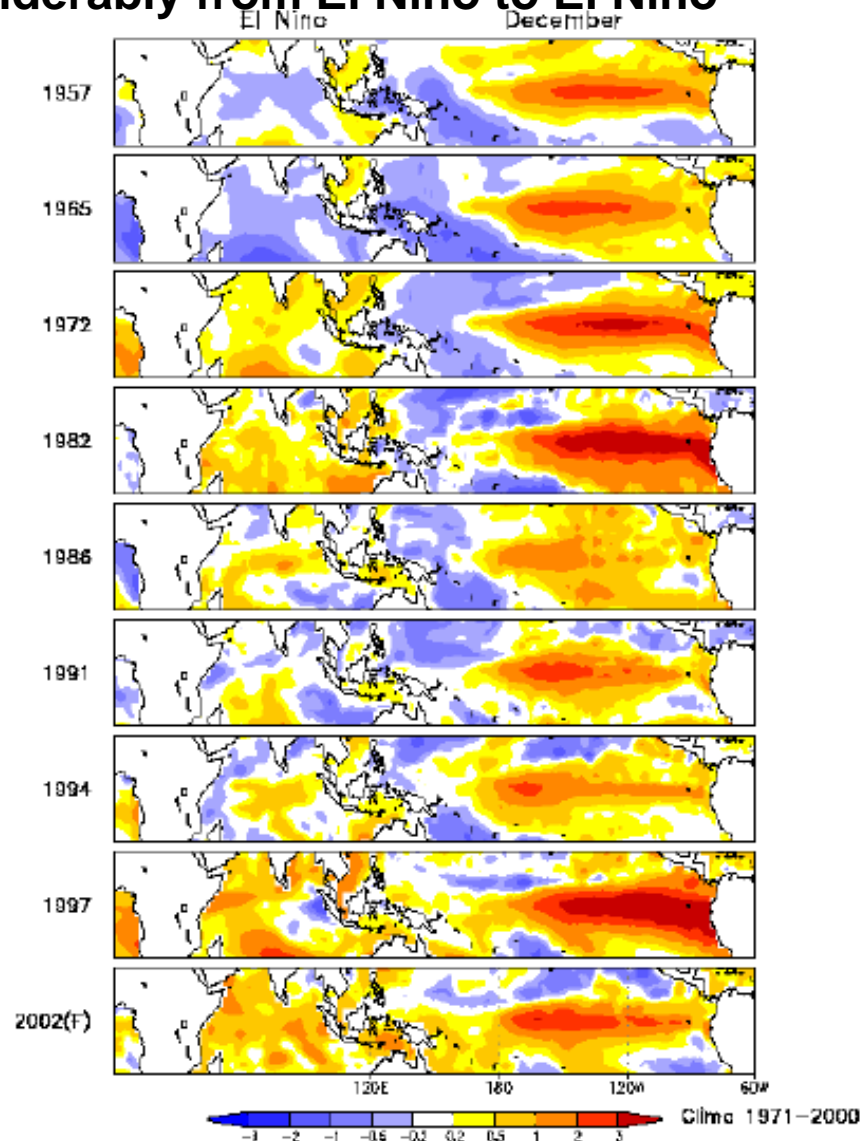
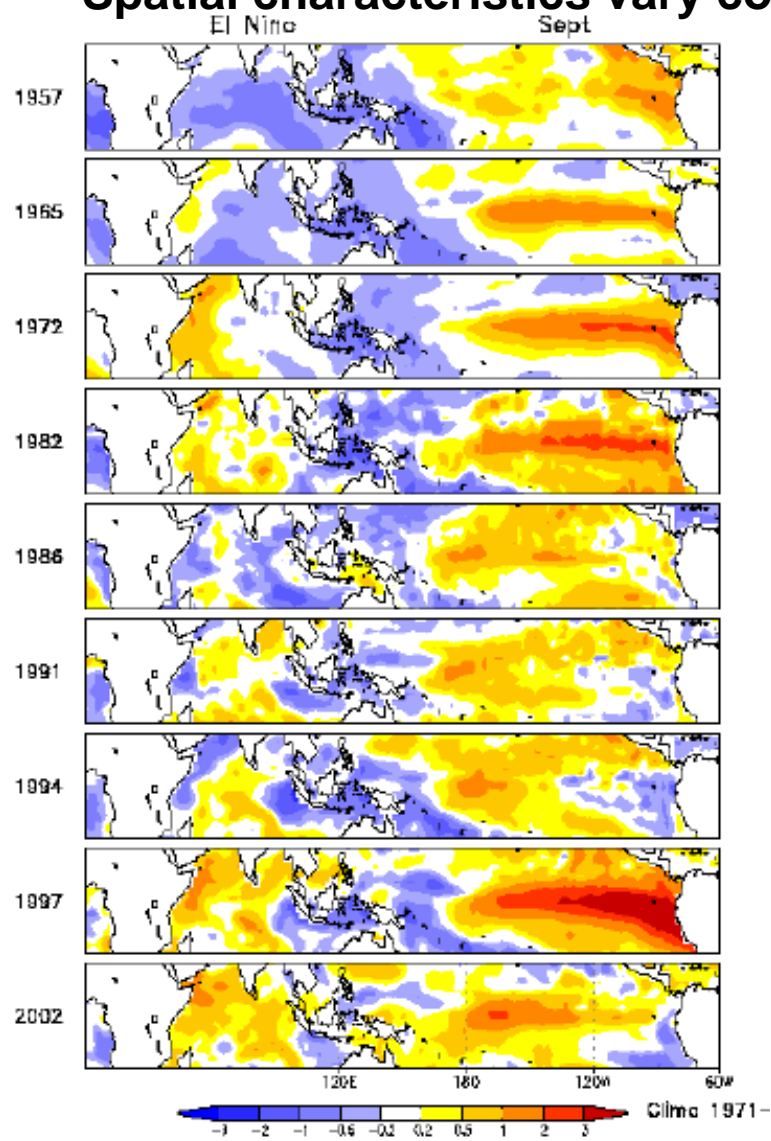


Neither are La Nina's

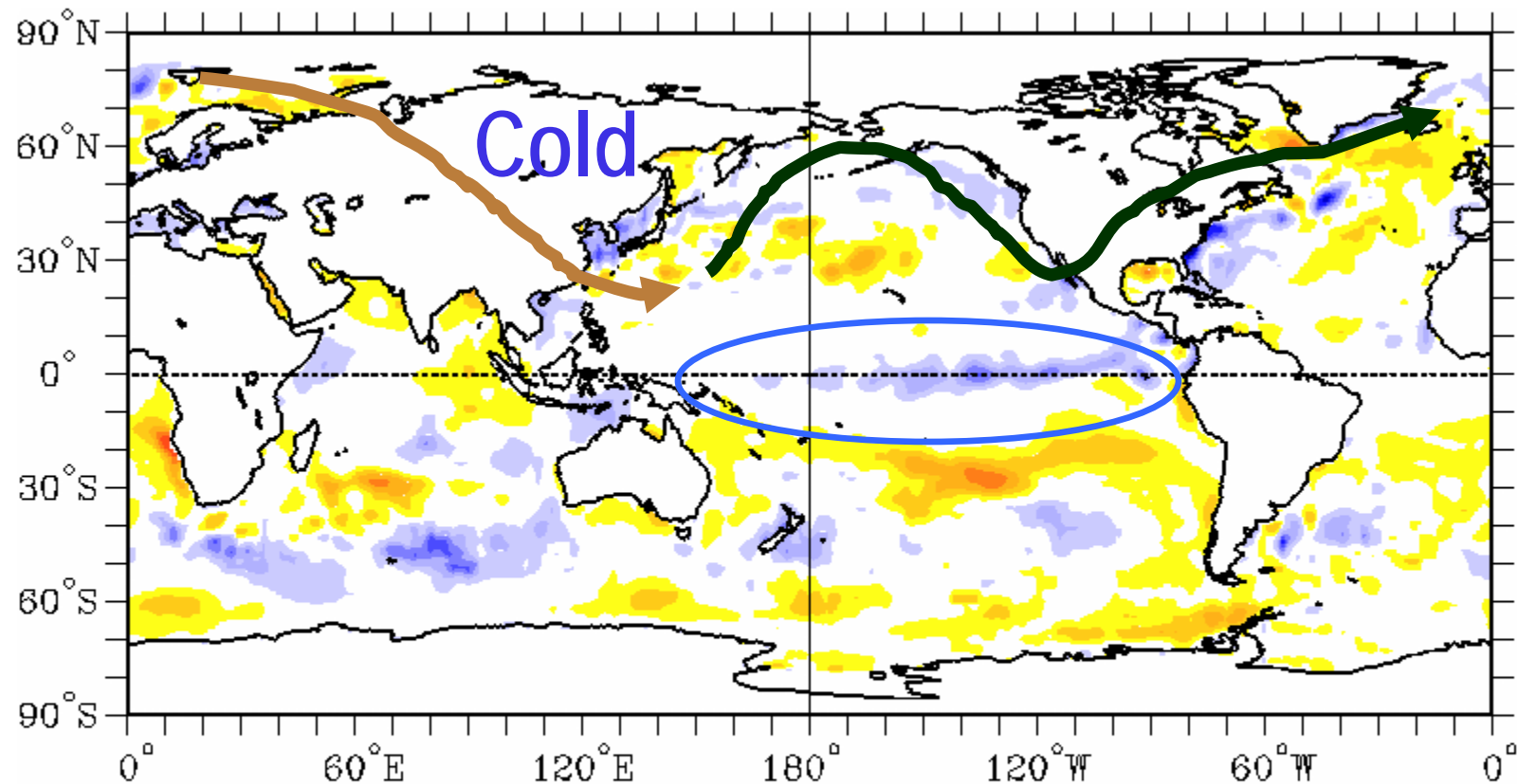
Multivariate ENSO Index for the 7 strongest historic La Niña events since 1949 vs. 1998-2000



Spatial characteristics vary considerably from El Nino to El Nino

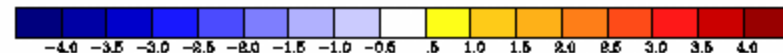


October to early Dec ST over Colorado =
Mtn snows and early October snow east.

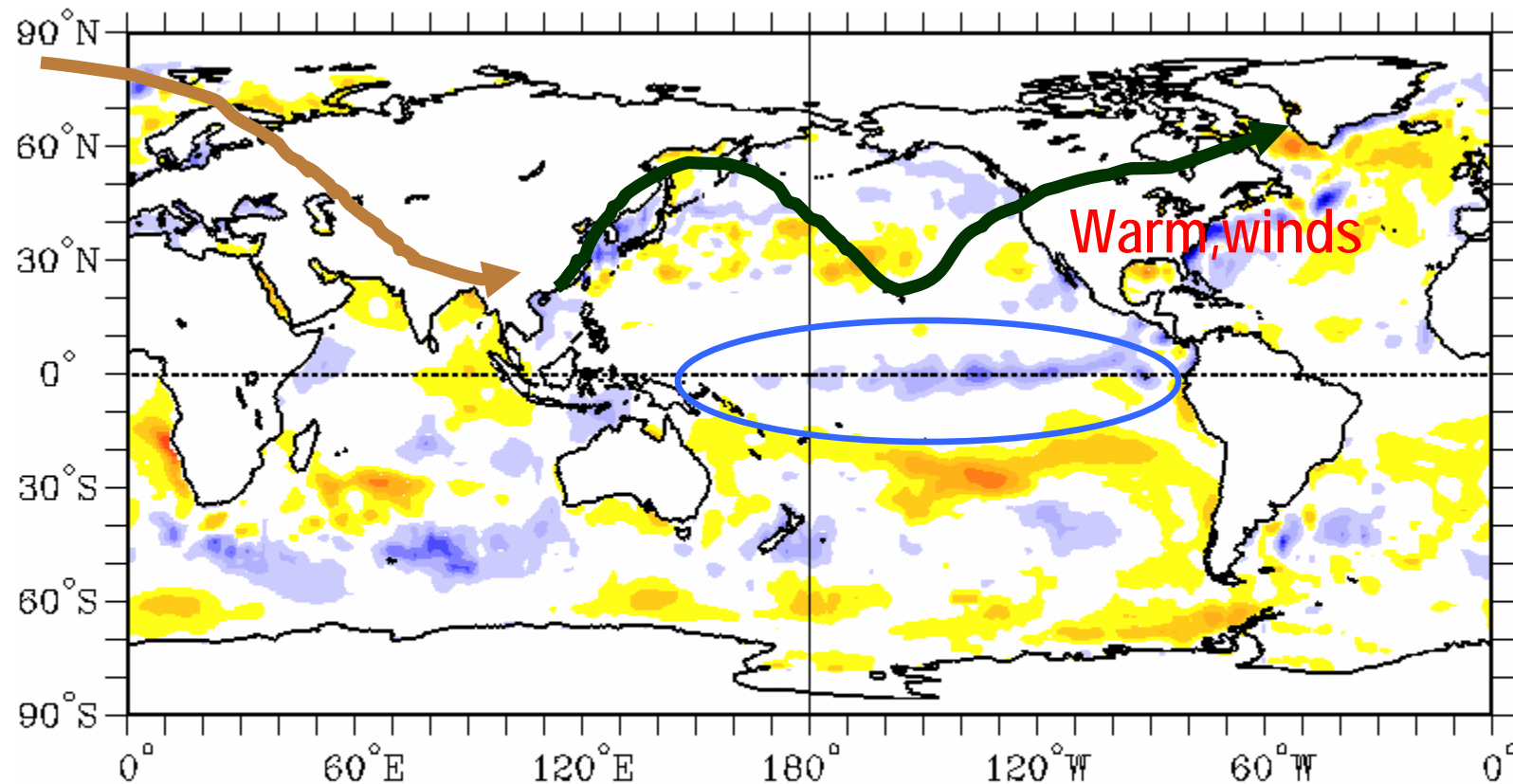


SST ANOM 3/ 5/06- 3/11/06

Base Period: 1982-96

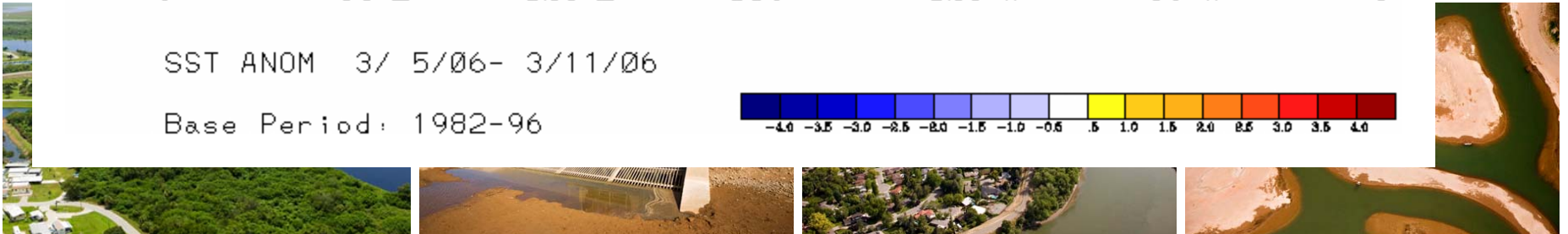
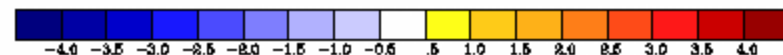


Mid-Dec to late Feb ST shifts west =
Windy dry Colorado, some mtn snow.

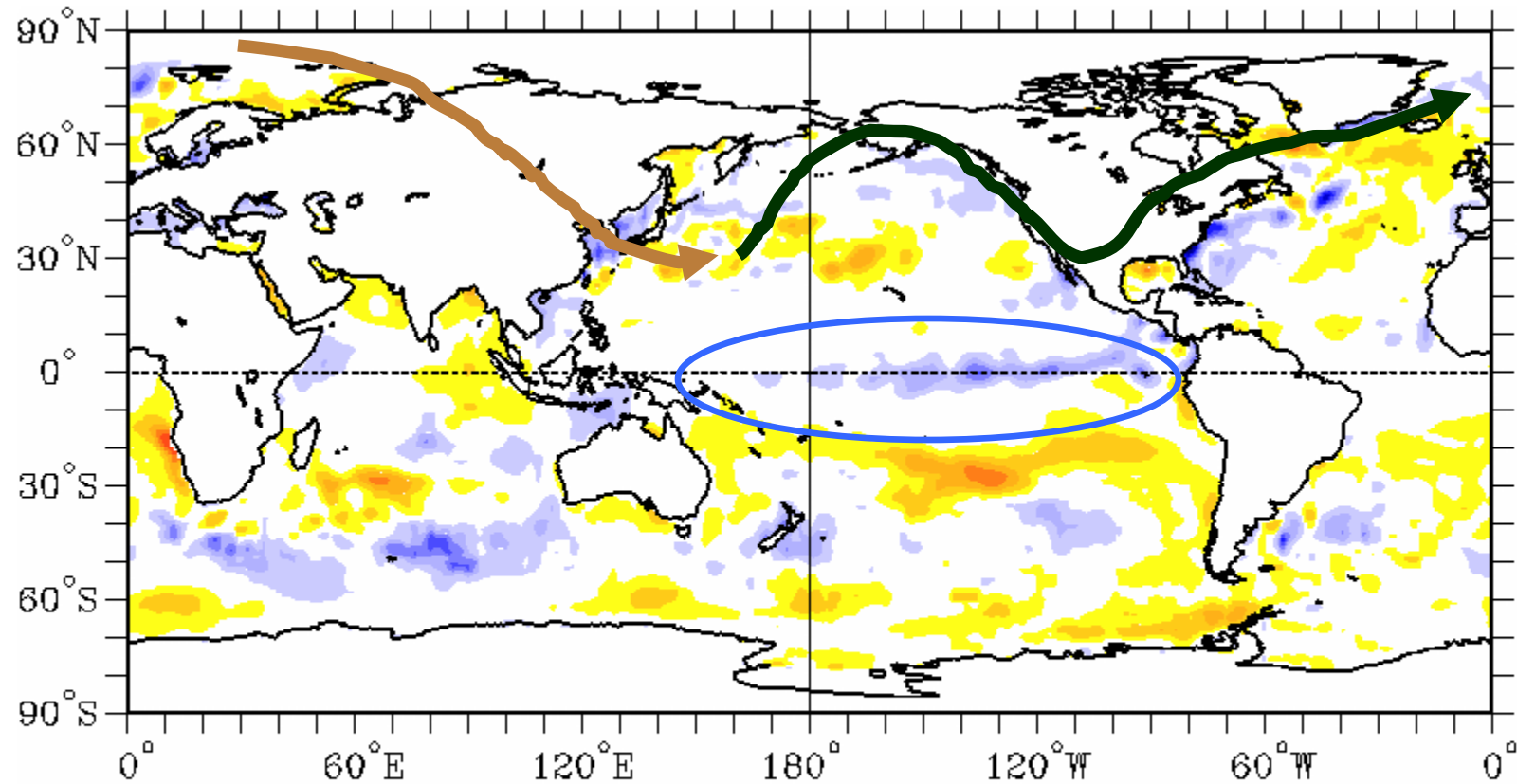


SST ANOM 3/ 5/06- 3/11/06

Base Period: 1982-96

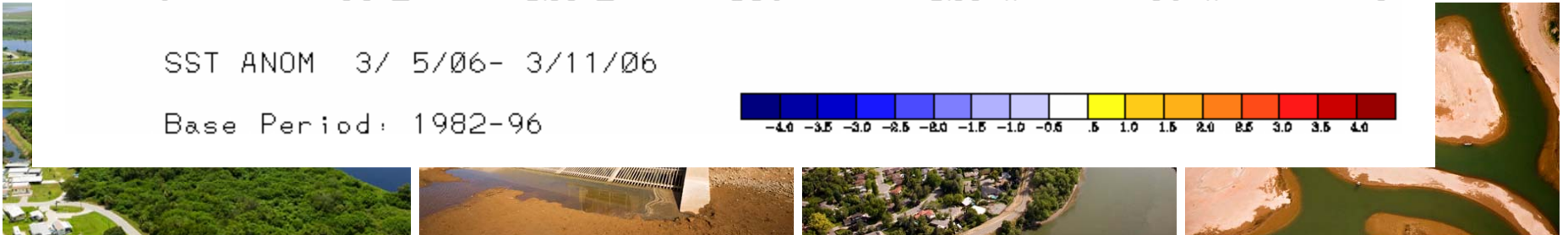
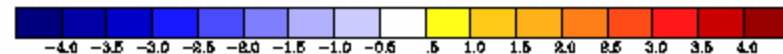


ST shifts again early March =
Return of spring snows statewide

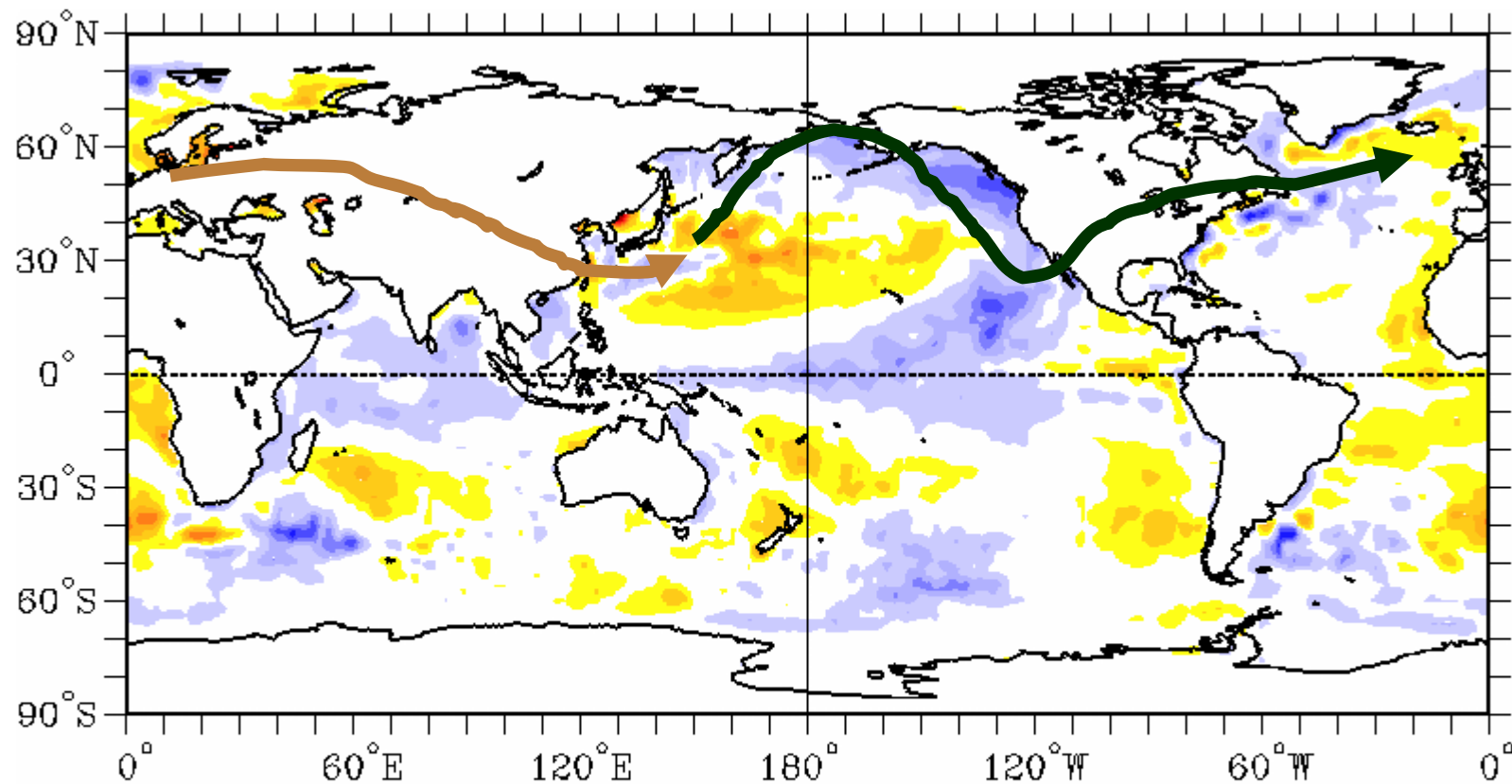


SST ANOM 3/ 5/06- 3/11/06

Base Period: 1982-96

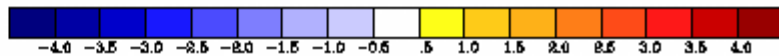


Spring storm track still rumbling

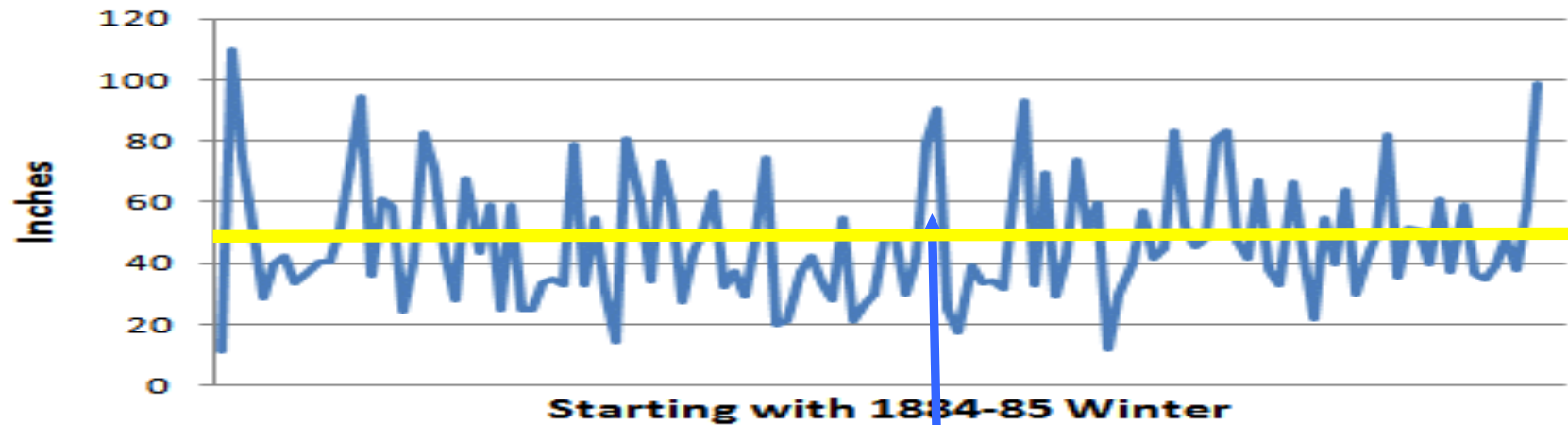


SST ANOM 4/27/08- 5/ 3/08

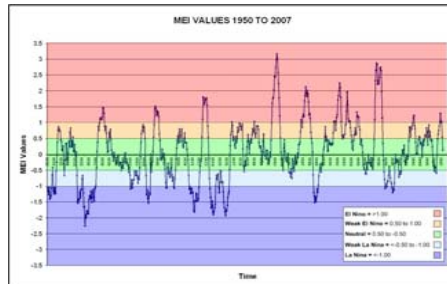
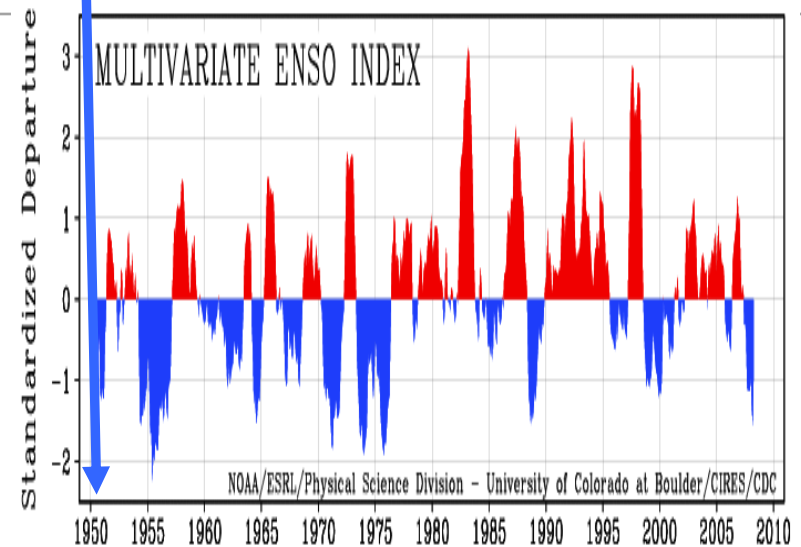
Base Period: 1982-96



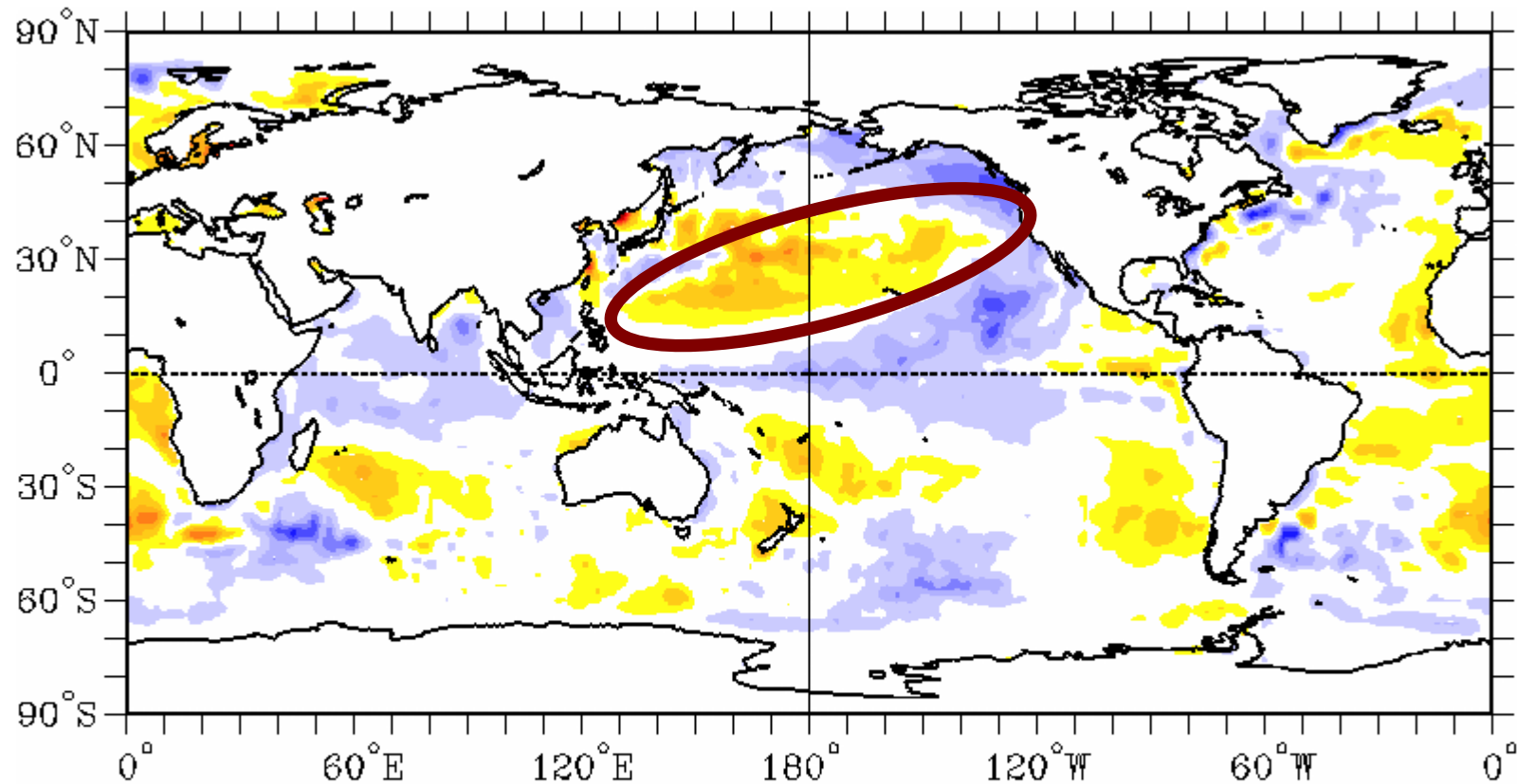
Milwaukee Winter Snowfall Totals



- Red = El Nino periods and less winter snow for MKE.
- Blue = La Nina periods and more winter snow for MKE.
- Avg MKE snowfall = ~47 inches

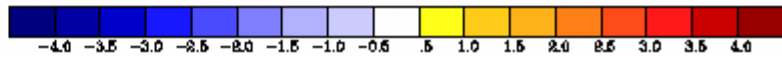


La Nina or El Nino? Some of both + El Pacifico.

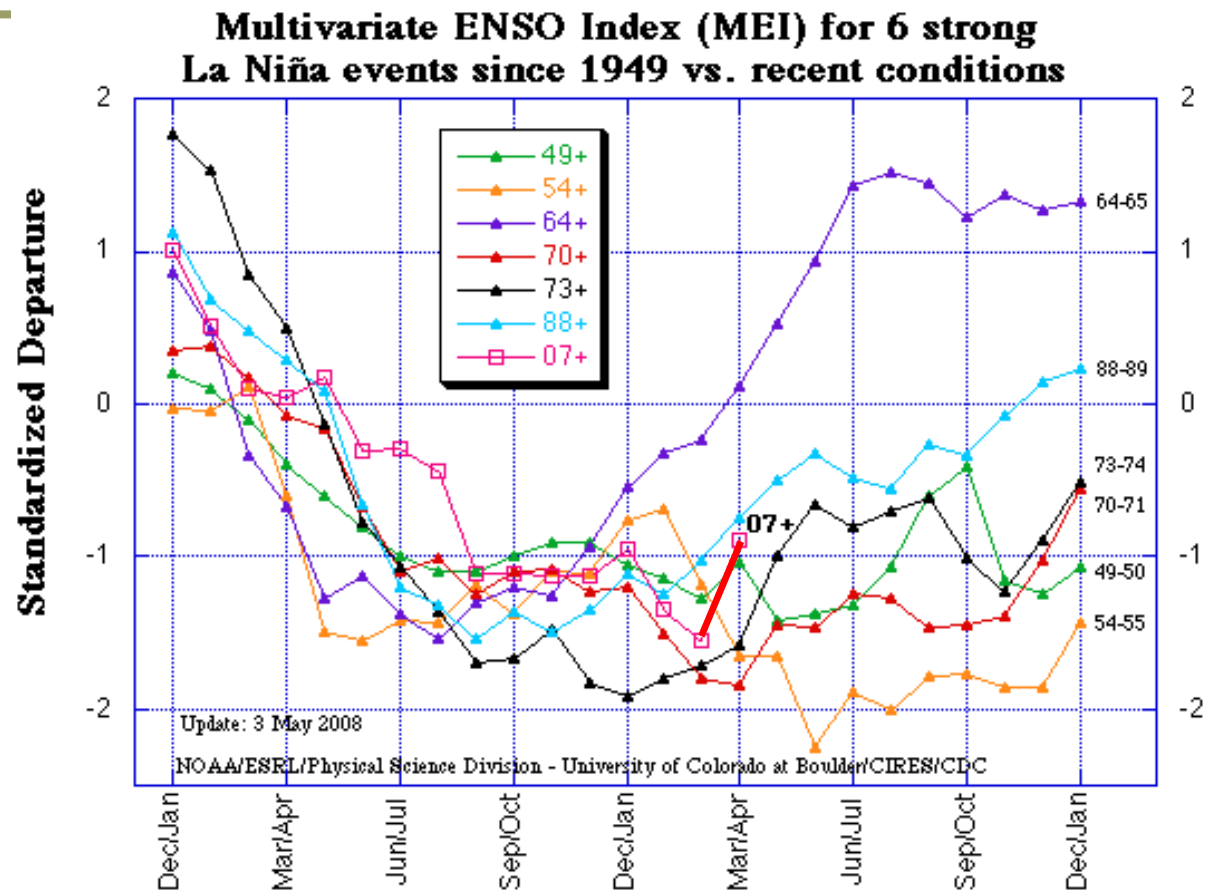


SST ANOM 4/27/08- 5/ 3/08

Base Period: 1982-96



Here's our current La Nina – where's it headed?



Personal insights into climate change

- The climate has always been changing – why are we “surprised” now by a period of warming?
- Our knowledge of climate variability, causes and extremes is in its infancy. Cause-effect relationships work!
- Prior design assumptions of “*climate stationarity*” were an unfortunate decision based on incomplete knowledge.
- We tried to engineer out the need to understand weather and climate. It did not work!



Personal insights into climate change

- The joint impacts of population density and growth, stressed infra-structure and natural climate variability will be identified as the *real problem* within decade or less.
- We will realize that the most significant “man-made climate change” is the “**local and regional urban heat islands**” and their influences created by increased population density, inefficient buildings and paved landscapes.

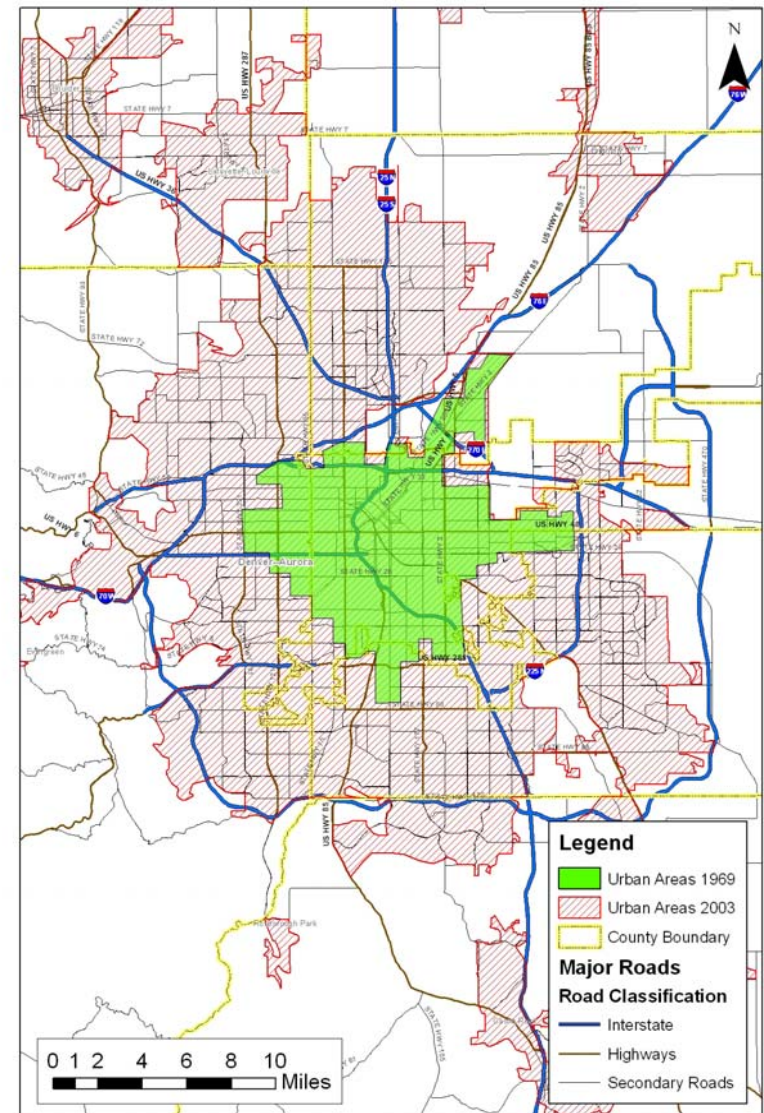


Urban heat island in Denver increased over past 34 years

- Green area is urban boundary of population in 1969:
~ 750,000
- Grey area is urban boundary of population in 2003:
~ 2.5 million



Urban Boundaries 1969 vs 2003

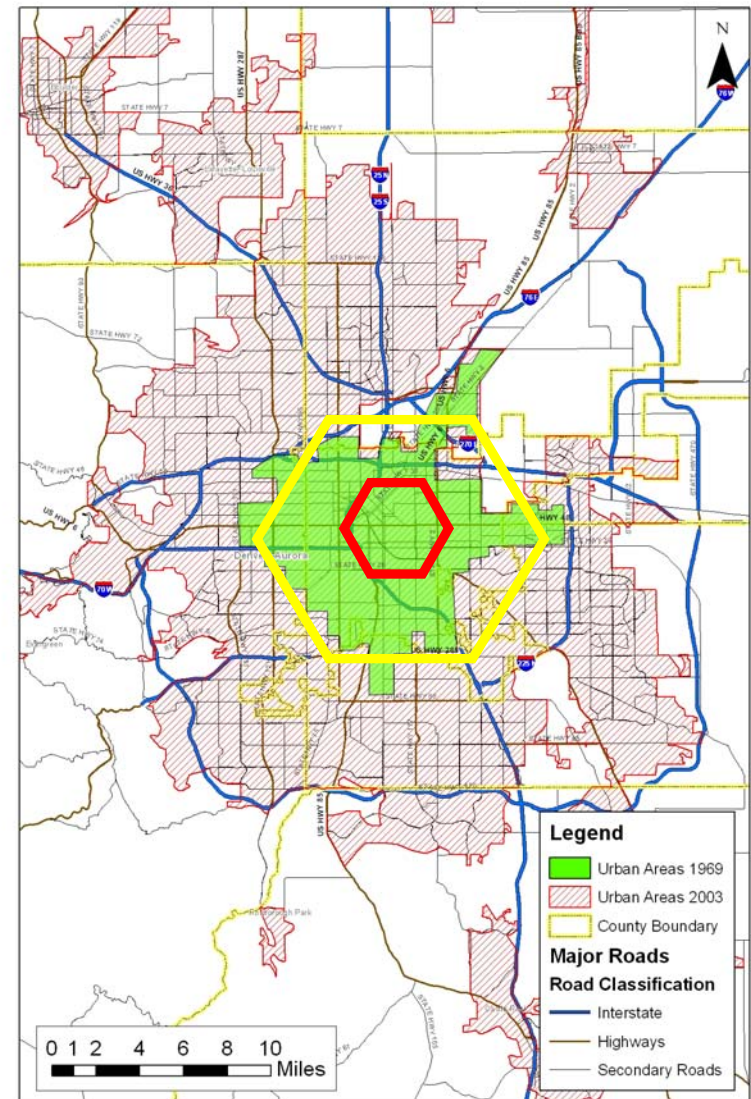


Urban heat island in Denver increased over past 34 years

- In 1969
 - Yellow line defines area where temperatures are + 3F warmer than Stapleton observations
 - Red line is + 5F warmer than Stapleton observations
 - *Preliminary estimates*



Urban Boundaries 1969 vs 2003

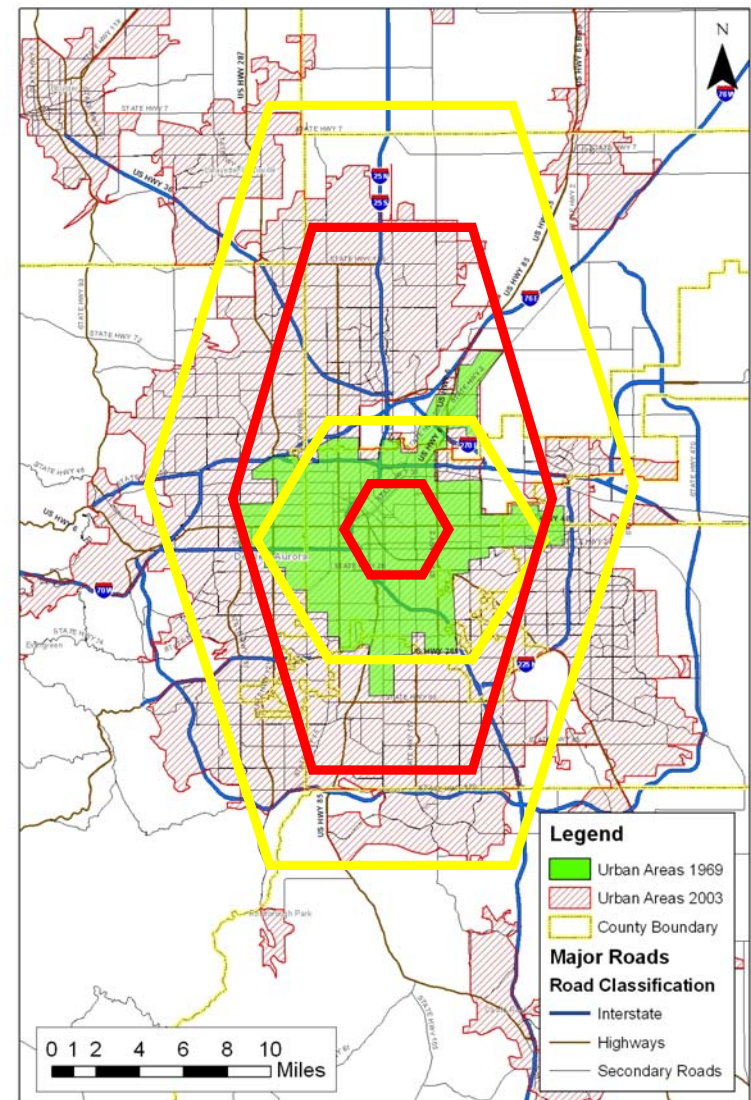


Urban heat island in Denver increased over past 34 years

- Compared to Stapleton – 1969 vs. 2003
 - Yellow line is + 3F warmer and increased by factor of ~ 6.5 in spatial coverage
 - Red line is + 5F warmer and increased by factor of ~20 in spatial coverage
 - Can be pro-rated by population growth, vehicle population, types of building heat emissions, etc.
 - *Preliminary estimates*

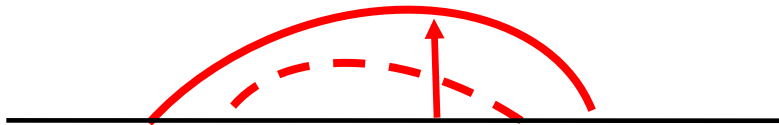


Urban Boundaries 1969 vs 2003

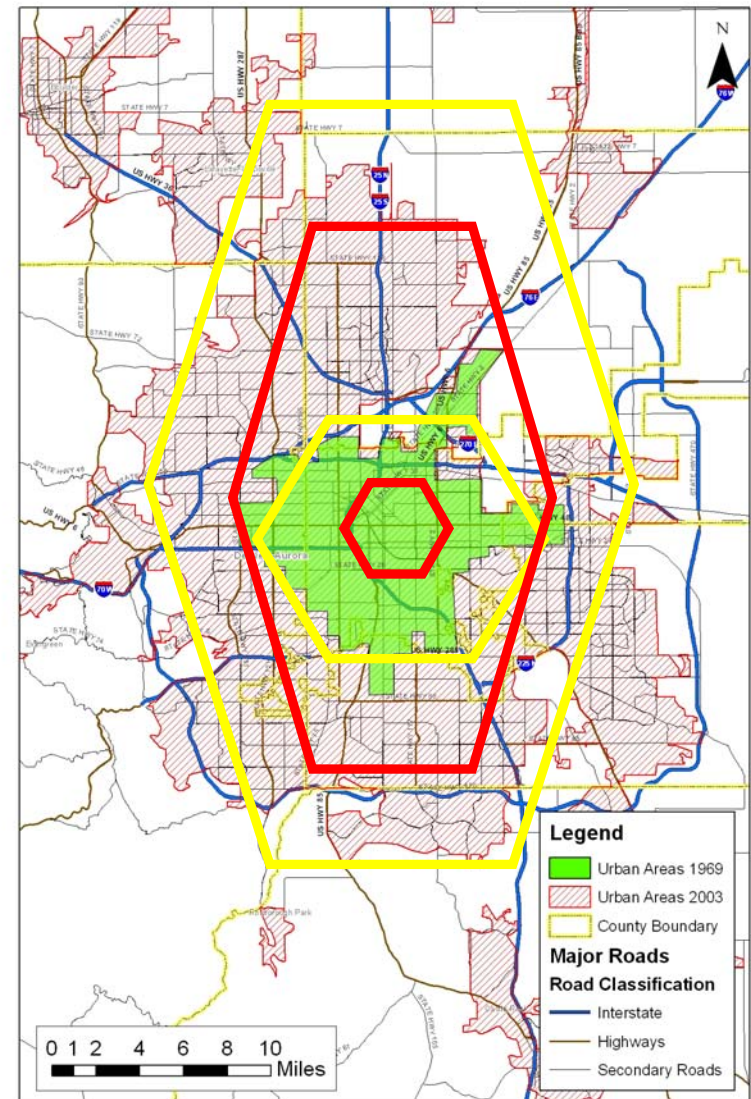


Urban heat island in Denver increased over past 34 years

- Compared to Stapleton - 1969
 - Red area warmer than 5F has increased in depth from ~300ft to about 900ft or 3 times deeper
 - Thus the “heat island” has increased in spatial coverage and depth (i.e., volume)



Urban Boundaries 1969 vs 2003



Personal insights into climate change

- Our biggest challenge may be meeting the demands for water and electricity in our highly urbanized, population centers and corridors with aging infra-structure.
- These high stress areas are clustered in and along the East and West Coasts, the Great Lakes and the Gulf Coast.
- We will become very surprised in the next decade by *our increased knowledge of climate cycles* and interactions between the atmosphere, oceans and the sun.



Personal insights into climate change

- 50-100 years ago our infra-structure was designed to meet a 100-yr or PMP design storm or situation. We could experience a 100-yr situation and meet demand.
- The joint dynamics of population density and aging infra-structure may have reduced our “climate variability tolerance” to 10-yr to 25-yr events before the delivery system becomes stressed by demand.



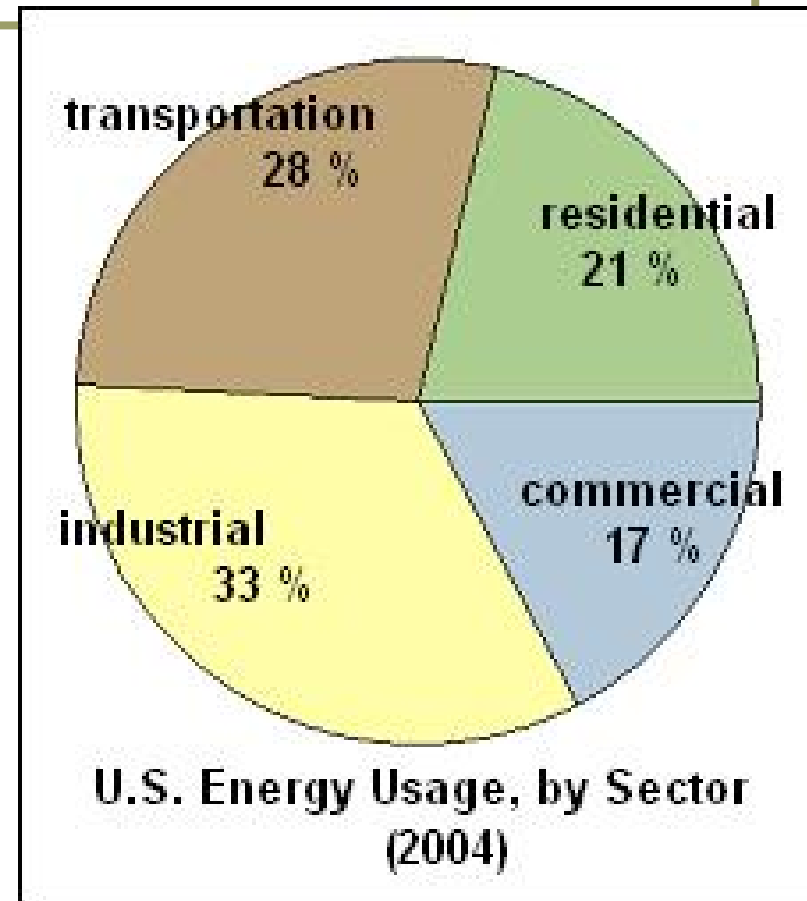
Personal insights into climate change

- In high population areas water and energy demand stresses delivery systems whenever we experience weather events that vary by more than 20 percent from normal.
- Simply stated, "*we have become more a weather-sensitive society*". Is global warming the cause or has it become a convenient scapegoat for our lack of planning?



The National Challenge

- Transportation now uses almost a third of US energy consumption
- Buildings use almost 40%



“The Triple Bottom Line” *another key*

Finding solutions within the “Triple Bottom Line” provides multiple right answers

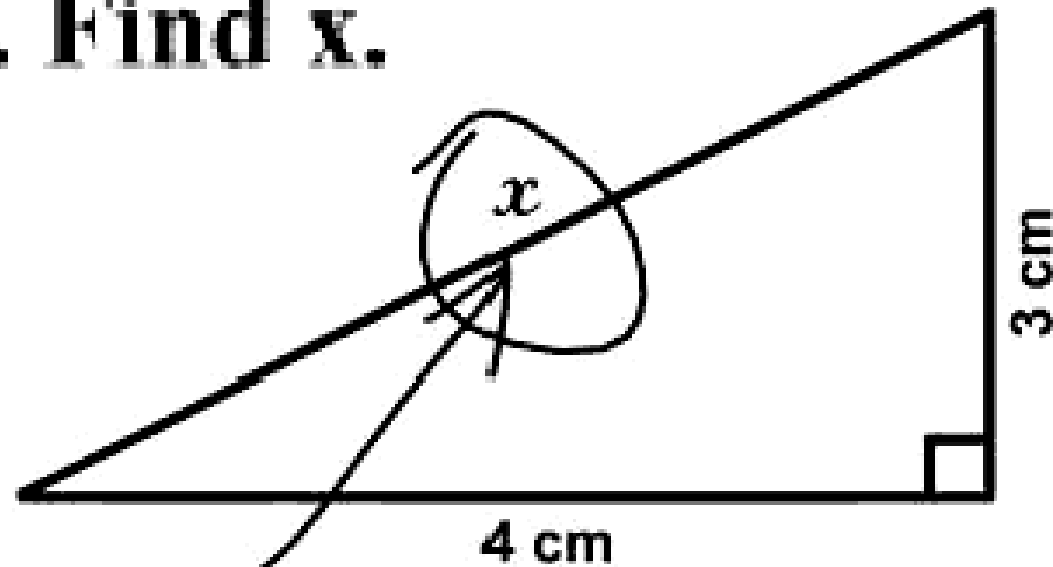


So how do we solve the problems?



Answers to a test

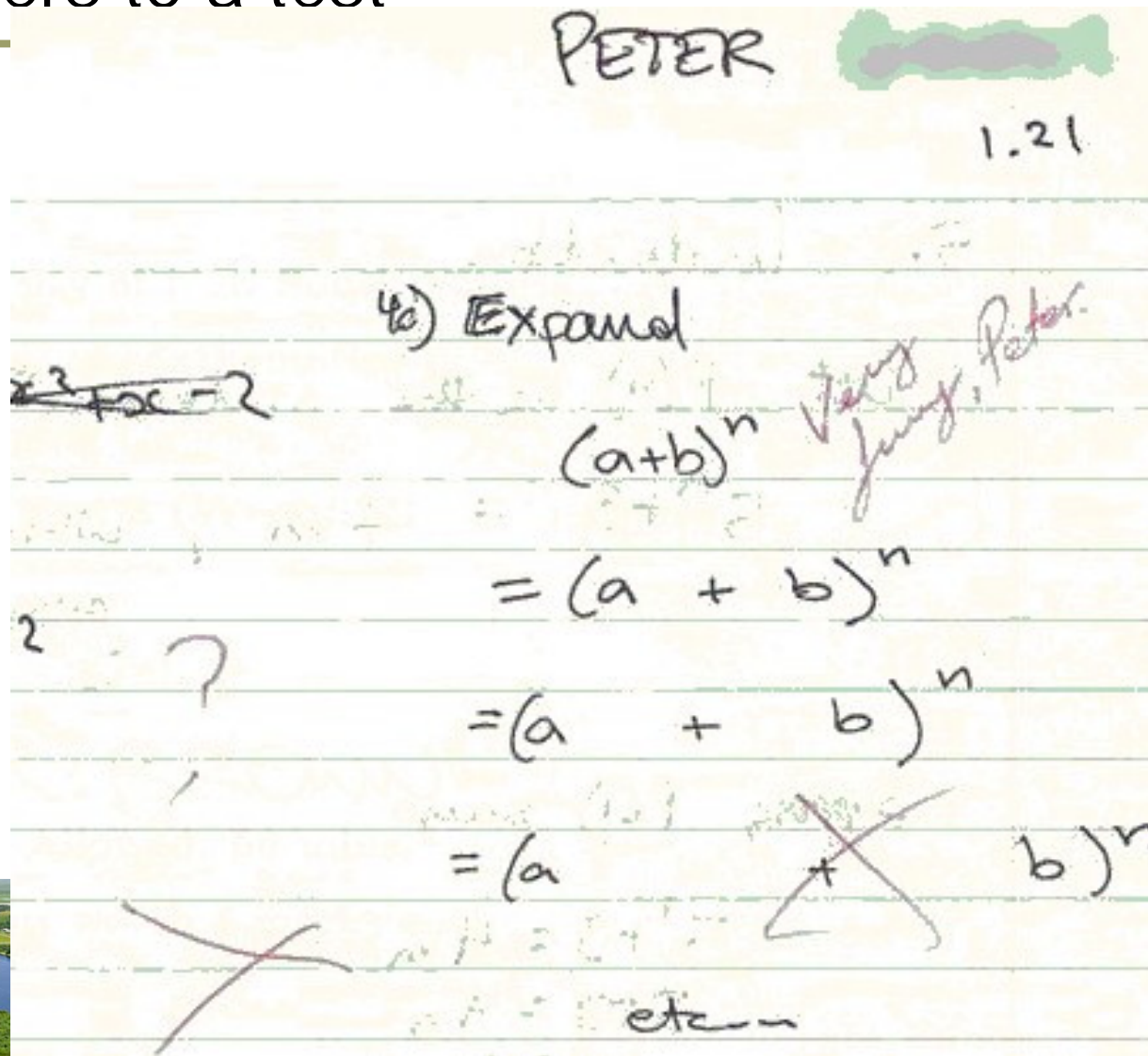
3. Find x .



Here it is



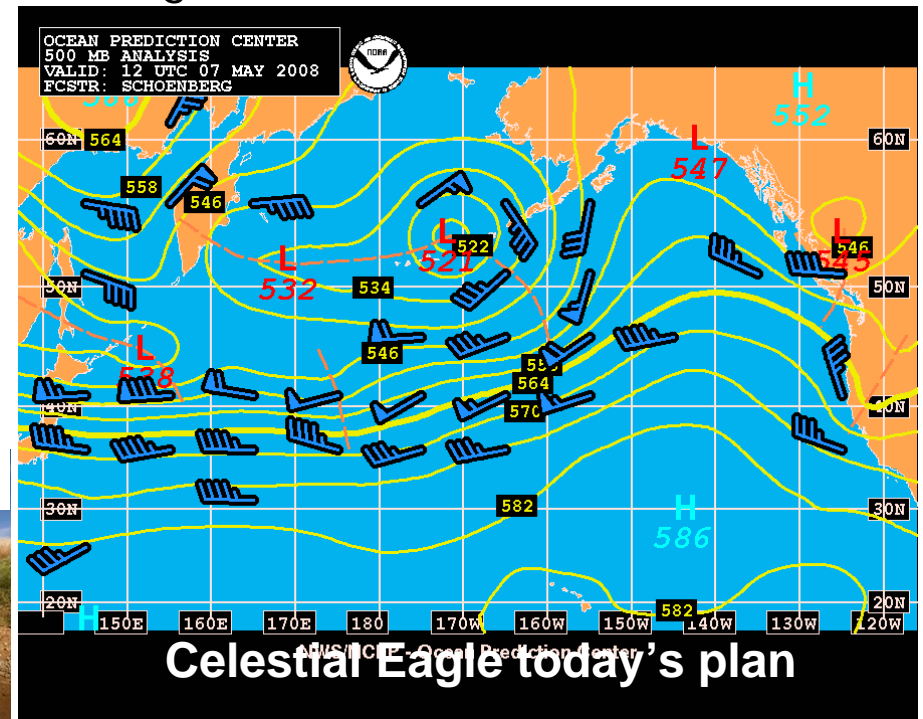
Answers to a test



How to get a free-flying balloon across Pacific?



- Prior attempts across the Atlantic failed 14 times flying troughs and ridges.
- First in 1873 failed and Double Eagle II made it in 1978.



Flight track of Double Eagle V



- Flight from 10-12 November 1981 from Nagashima, JP to Corvallis, CA.
- 84 hours and 31 minutes later, traveling a record 5,768 miles (9,283 km)
- Record **still stands** for manned helium balloon.
- Flew zonal flow path during evolving El Nino pattern.



QUESTIONS

*"Climate is what you expect;
weather is what you get"*

- Robert A. Heinlein

Email: john.henz@hdrinc.com



If time permits an example of working together

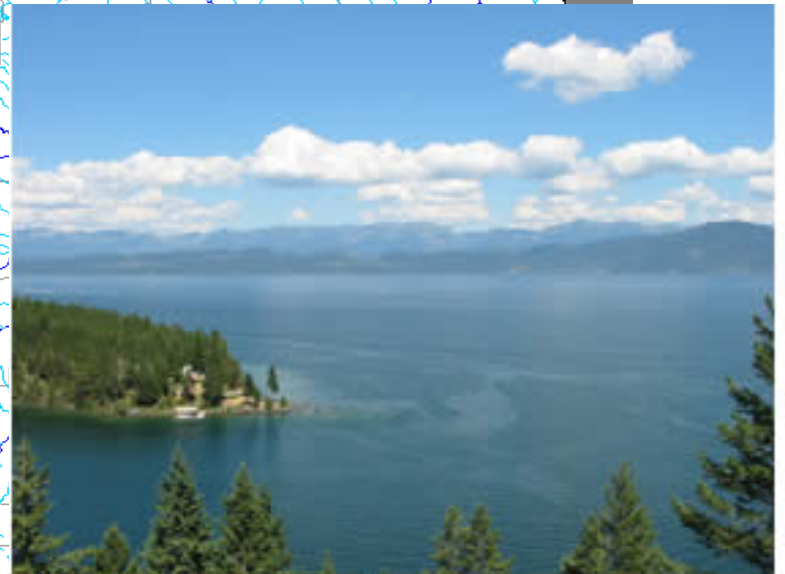
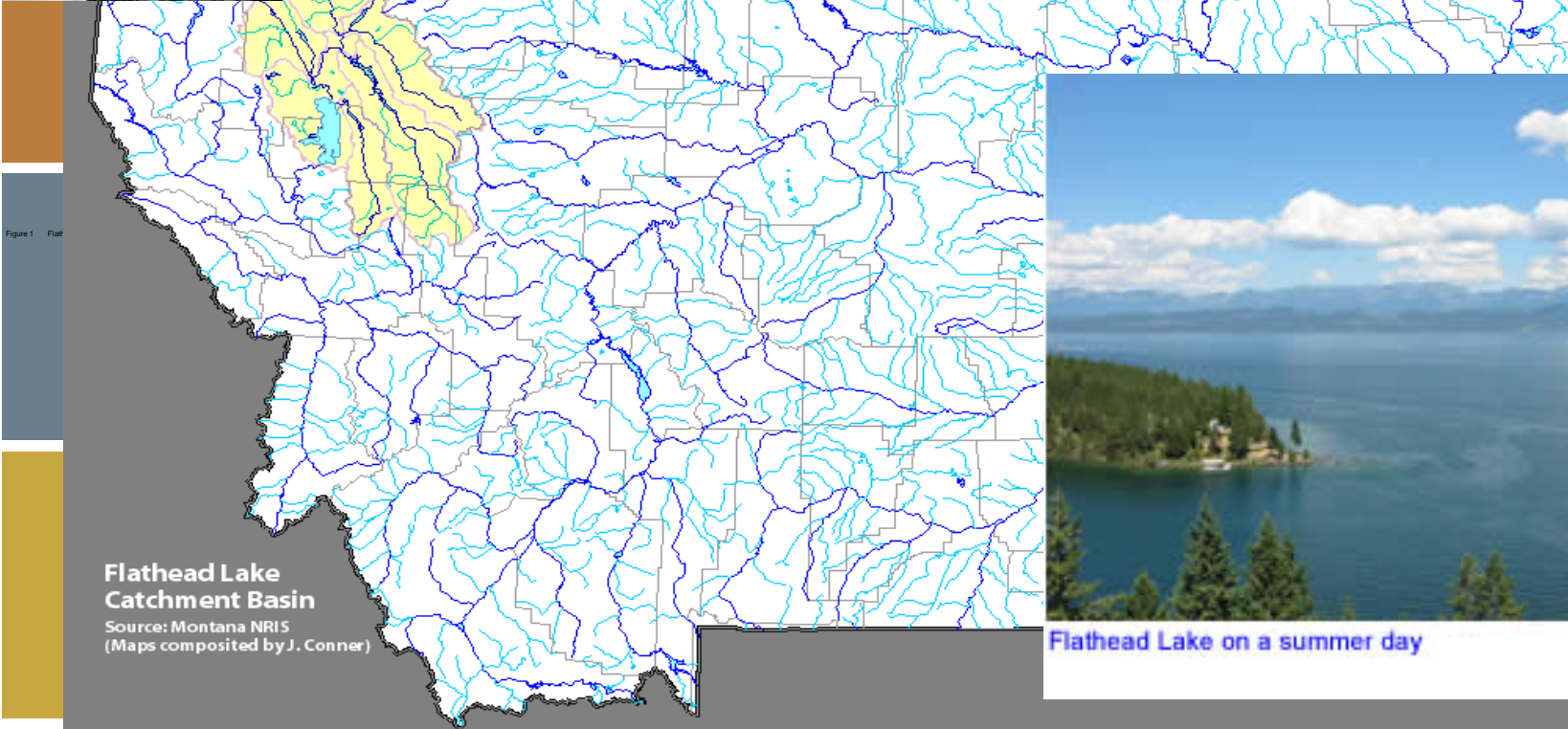
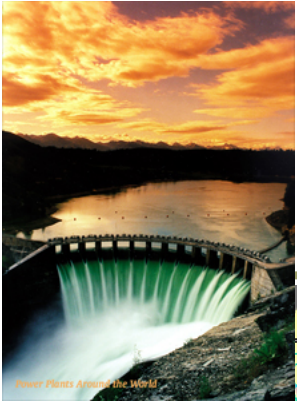


Flathead Lake Reservoir

- Dam operation hinged on operating rule curves and several forecasts:
 - NRCS
 - NWS/RFC
 - BuRec
 - COE
- All forecasts were based to a degree on “climate stationarity” assumptions with observed snow pack SWE, SOI and next following months’ assumed average precipitation to predict runoff volume and average timing.



Montana Rivers and Flathead Basin

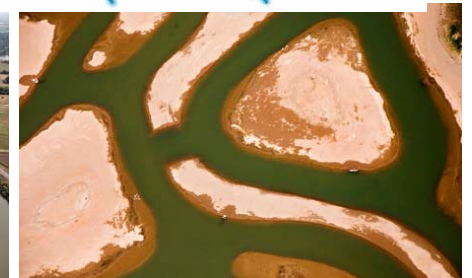
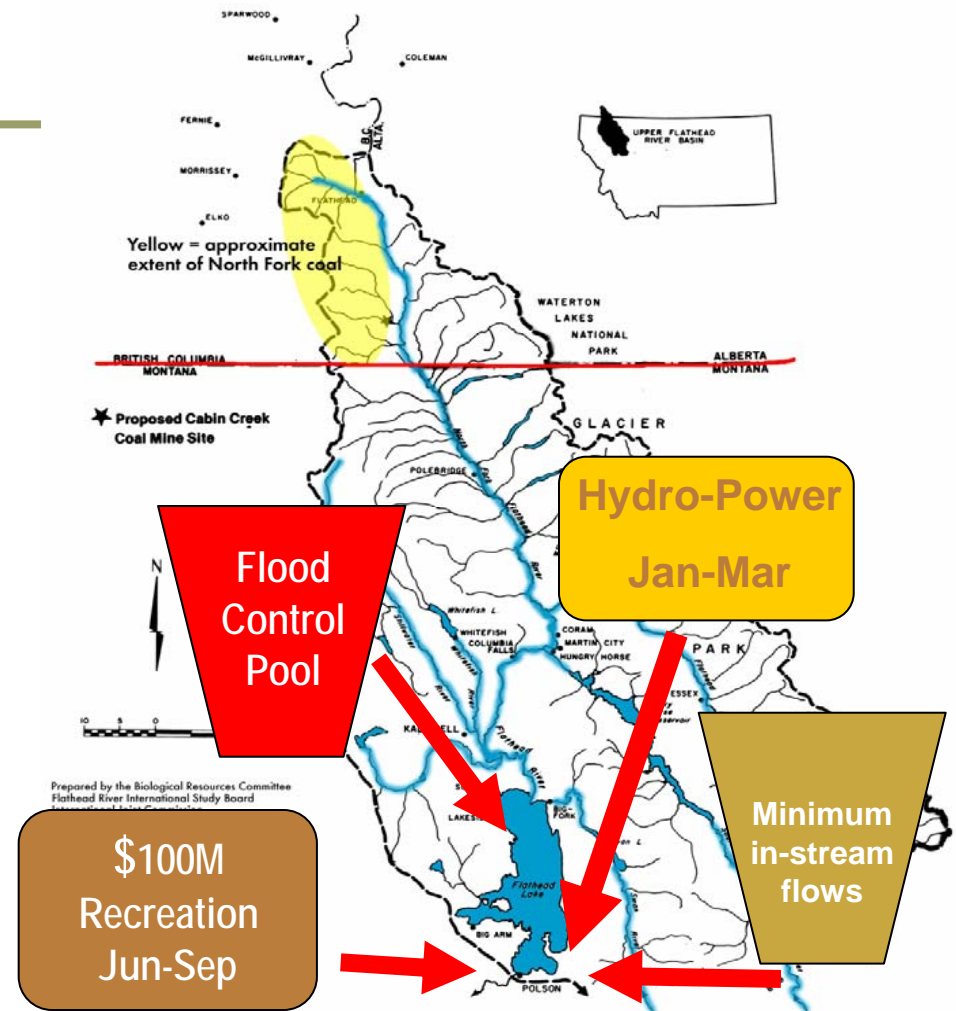


Flathead Lake on a summer day



Why is a drought management plan needed for Flathead Lake?

- Major Rivers draining into Flathead Lake Basin dependant on winter snow-pack and spring rains.
- Summer Recreation Industry \$100 Million – lake level crucial.
- Hydro-Power Generation at Kerr and Horse Thief Dams – draws down lake levels = power gen.
- COE maintains a flood control pool for spring runoff floods.
- Additional concern is minimum in-stream flow for endangered fish.





Starting Point: Normal vs. El Nino vs. La Nina Basin Precipitation

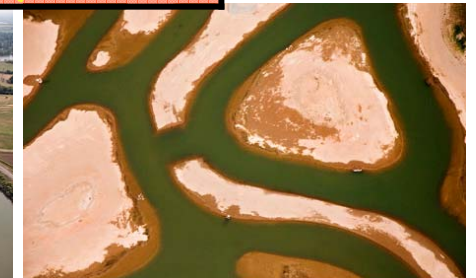
**Climate
Stationarity
assumed in
rule curves**

Regime	Oct-Dec Inches (+/- avg.)	Oct-Mar Inches (+/- avg.)
La Nina = Wet	6.82" (+1.49")	12.59" (+2.29")
Normal	5.33"	10.33"
El Nino = Dry	4.85" (-0.48")	8.52" (-1.81")
Driest 10 yrs = drought	3.25" (-2.08")	6.21" (-4.12")



10 Driest Water Years: Is Oct-Dec <3.50"?

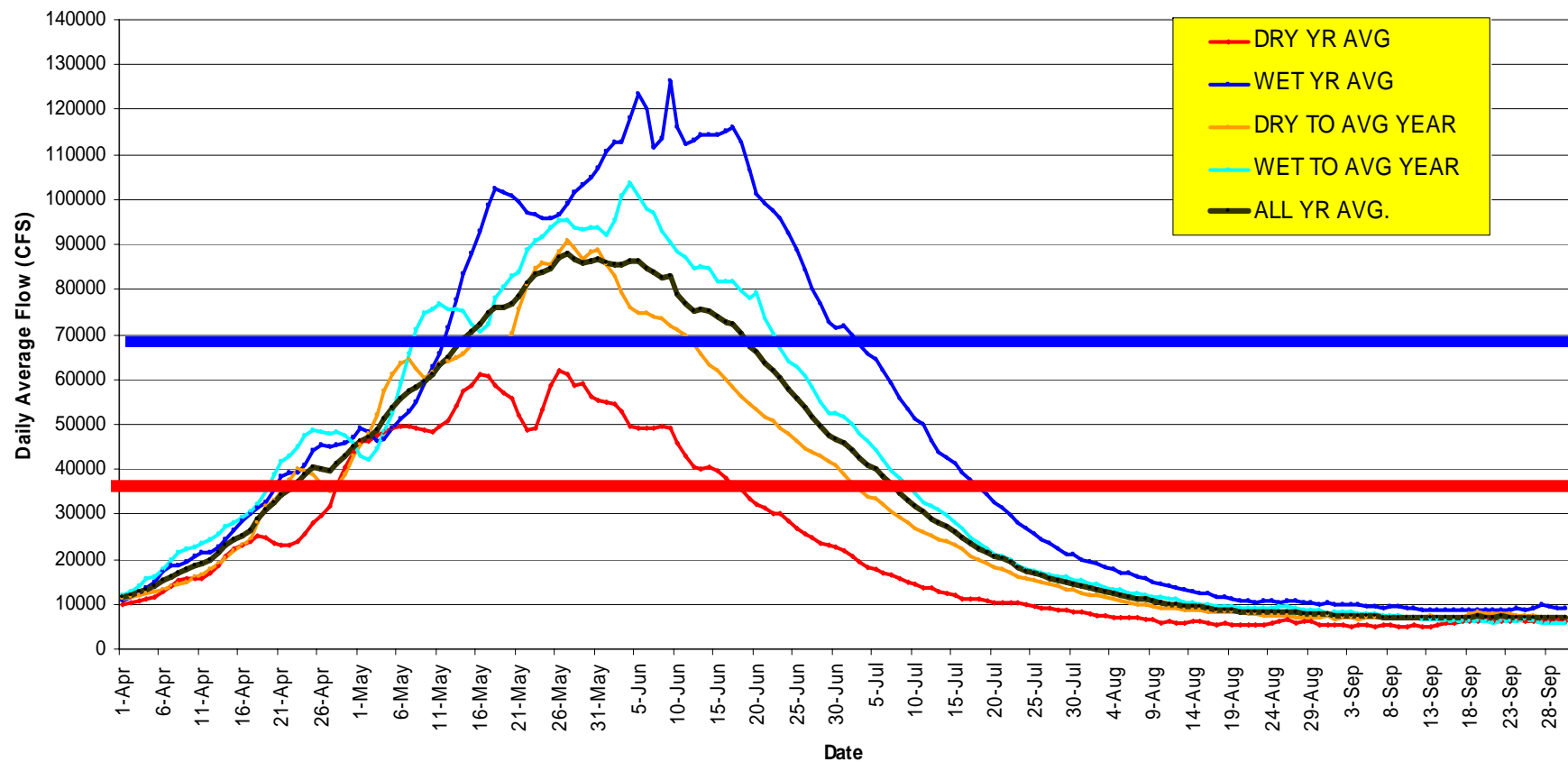
Year	Oct-Dec	Oct-Mar
1977	2.29"	5.35" (52%)
1944	3.49"	5.82" (56%)
1994	3.19"	5.83" (56%)
2001	3.12"	5.95" (58%)
1988	2.60"	6.16" (60%)
1941	4.72"	6.40" (62%)
1945	2.57"	6.50" (63%)
1905	3.38"	6.63" (65%)
1937	3.04"	6.77" (67%)
1973	4.52"	6.93" (68%)





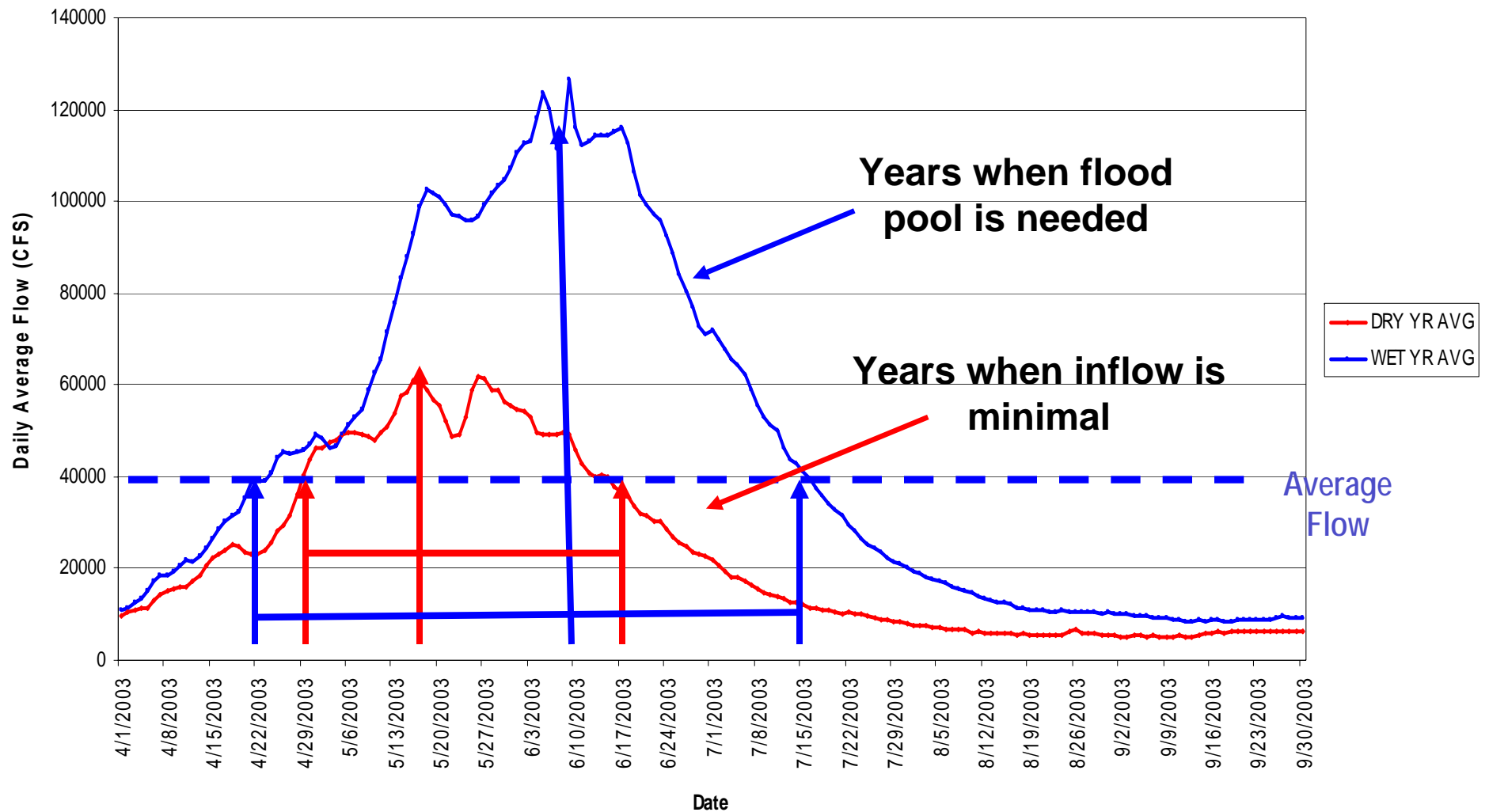
Comparison of key runoff hydrographs

Average Hydrograph of Naturalized Daily Flow into Flathead Lake (Water Years 1929-2004)
for various averages of April to September flow volumes



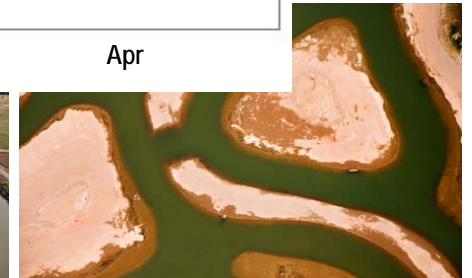
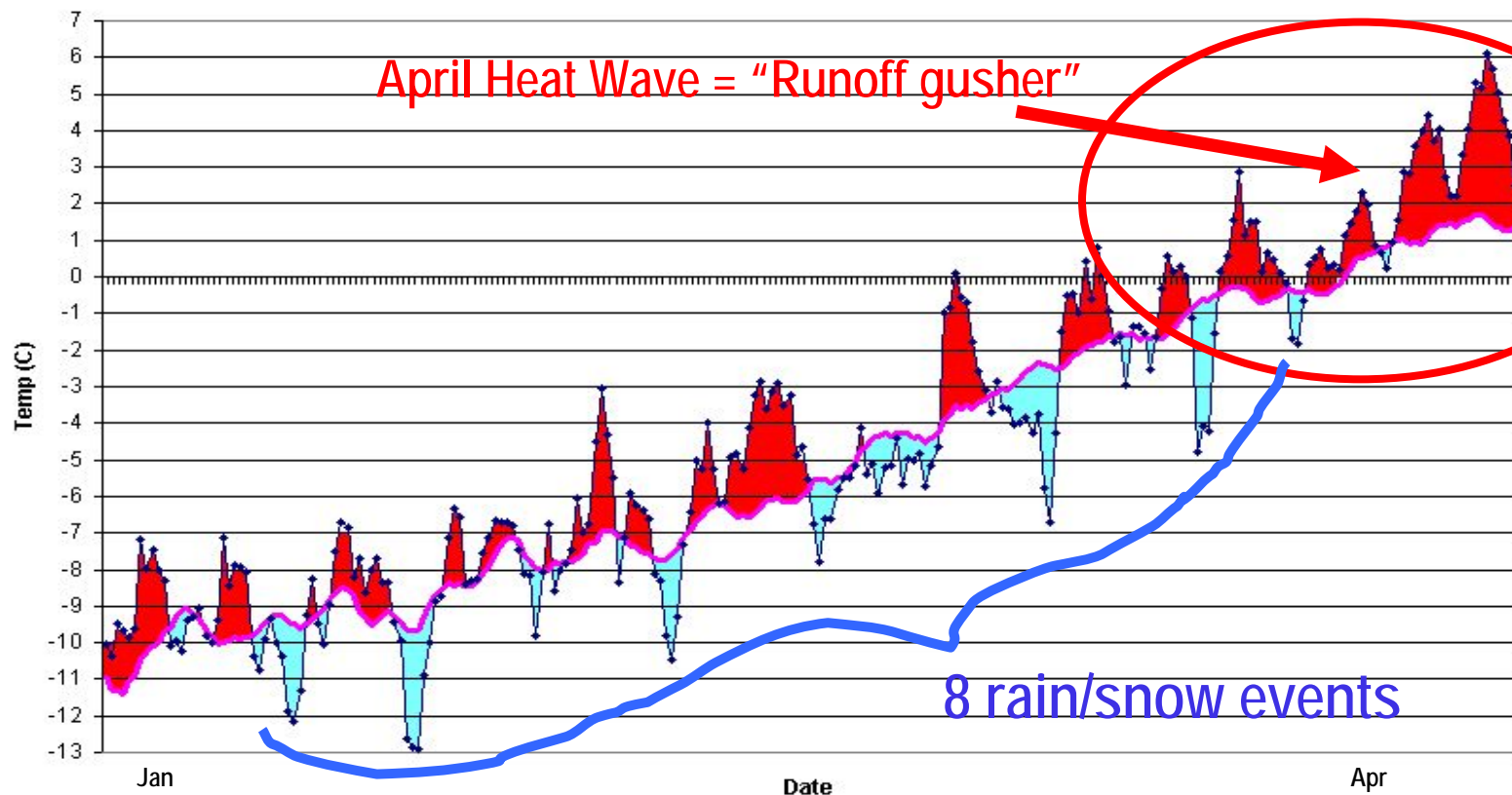
Compare Average Runoff hydrographs (average flow periods and peaks) for wet/drought periods

Wettest Years (15 total) vs. Dry Years (14 total) for Naturalized Flow into Flathead Lake (1929-2004)



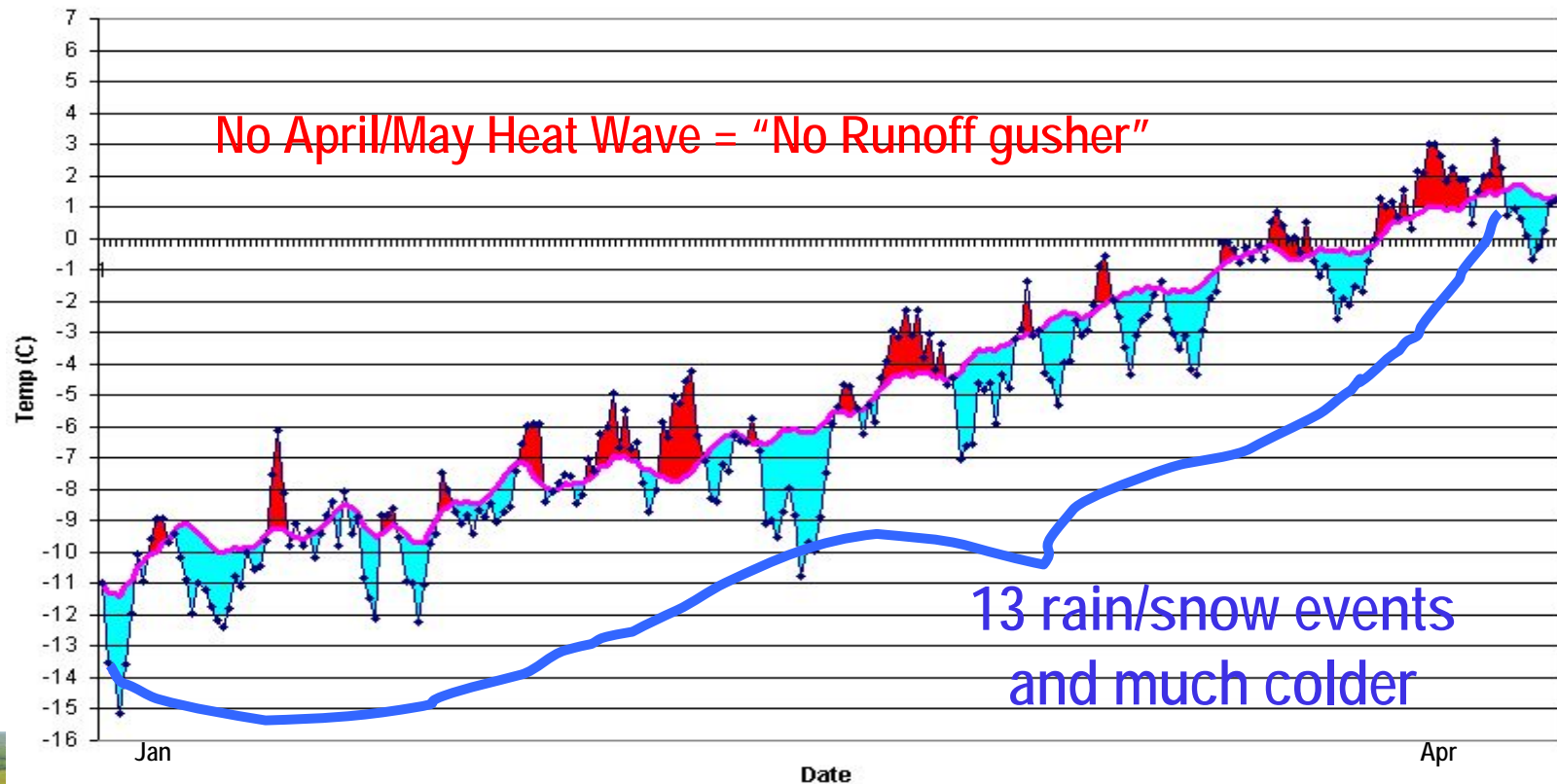
"Snapshot" of 'Dry Year' 700mb Temperatures at Spokane, WA vs. All Years' Average (7 driest years)

Comp. of 700 MB Temp. at Spokane (Dry Year Average) vs. Long Term Average (Apr 1st through June 30th)



'Wet Year' 700mb Temperatures at Spokane, WA vs. All Years' Average (9 flood years)

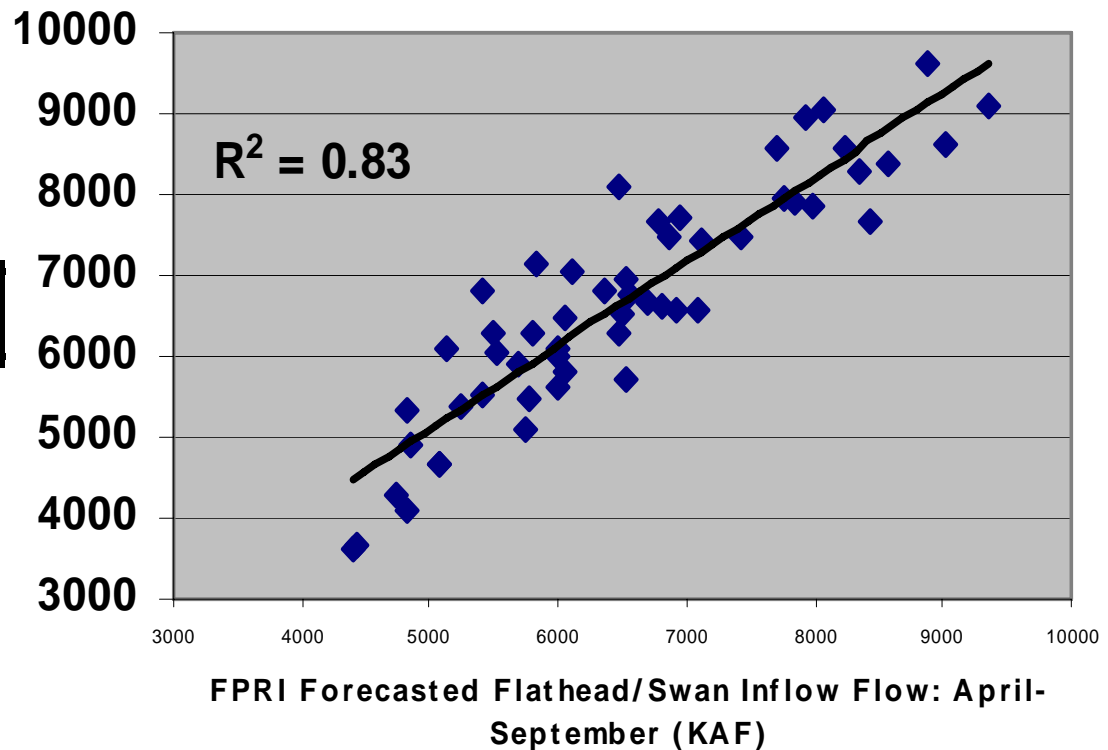
Comp. of 700 MB Temp. at Spokane (Wet Year Average) vs. Long Term Average (Apr 1st through June 30th)





FPRI = Flathead Precipitation Runoff Index (W. Badini)

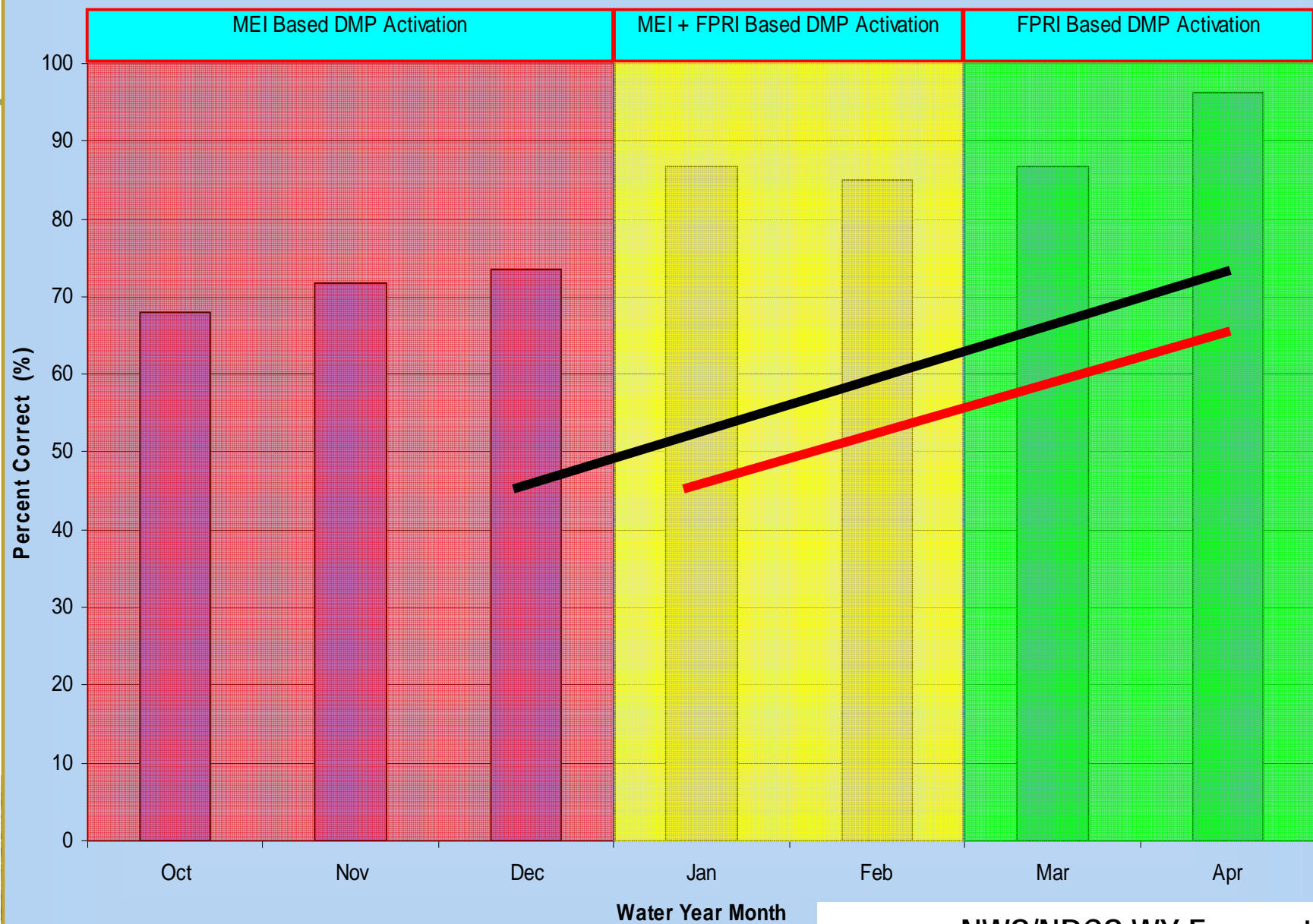
Comparison of FPRI Early April Forecast vs. Verified
Naturalized April-September Flow for 1951-2003



Precipitation data used was from valley floor climate stations not Sno-Tel in the snowpack



Flathead Lake Drought Management Plan
Percent of Water Years (1951- 2003) from October to April with Correct DMP Activation Decision



— NWS/NRCS WY Forecast

QUESTIONS

*"Climate is what you expect;
weather is what you get"*

- Robert A. Heinlein

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