Soil Renaissance: The Challenges of Changing Climate

FARM FOUNDATION ROUND TABLE JUNE 2014

Conclusions

- **Climate change is not linear. It ebbs and flows.**

- **Because of the recent Polar eruptions, there was a cooler, stormier Midwestern and Eastern winter and spring and a volatile early summer. Drought should increase in California. Two large equatorial volcano eruptions will shape the next 3 years.**

- **The warm phase of the AMO has created hotter summers, and stormier winters, springs and hurricane seasons. This is increasing the risk of flood contamination and erosion east of the Rockies.**

- **There is an 80% chance of summertime El Niño conditions and a 65%+ chance of it lasting through winter into next spring. Historically, this means a quieter Atlantic hurricane season, a milder winter in the north and stormier winter in California and the southern tier of states.**

- **We have reached a tipping point. The PDO has changed and is creating more extreme weather and severe Western and Great Plains droughts.**

Basically the climate is determined by:

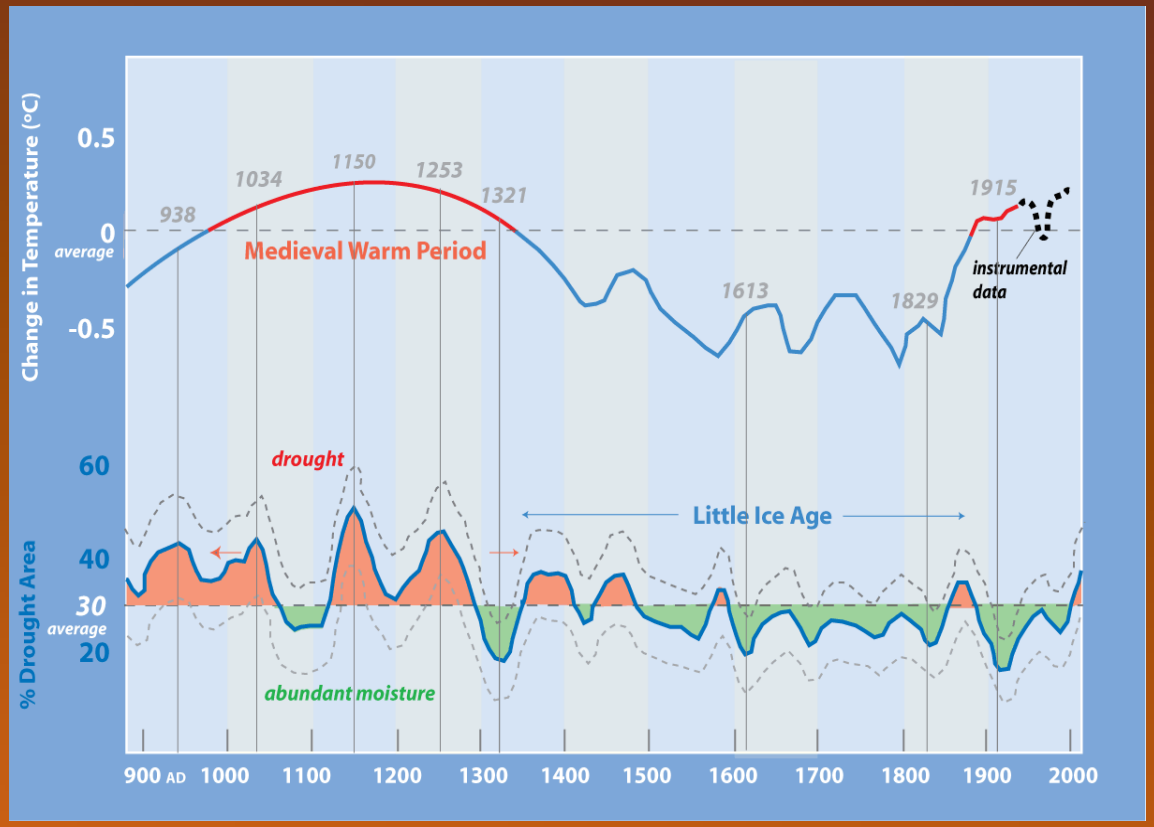
- How much solar radiation the Earth receives (the Sun)
- The patterns of where the solar radiation falls or is reflected (Clouds/Volcanoes)
- Where the heat from the solar radiation is stored (Oceans/Urban Heat Islands)

As an historical climatologist,
I look at what factors are shaping the weather and use:

Historical records, coral and tree rings,
sediment layers, and glacial cores to learn how they
shaped the weather in the past.

Historical records show that a change of 1˚ F changes the freeze zone 300 miles.

(1˚C changes the freeze zone 1000 km)

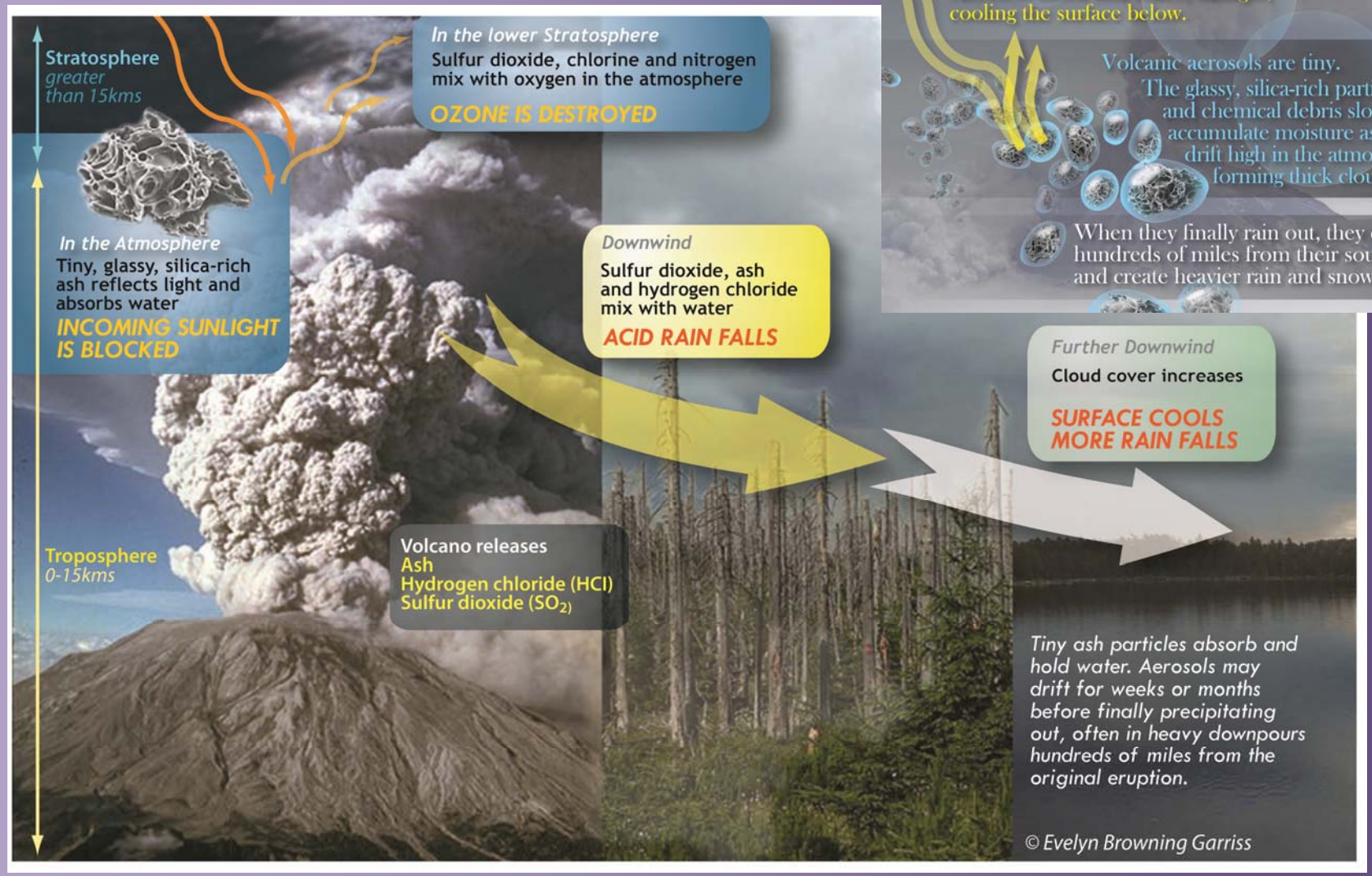


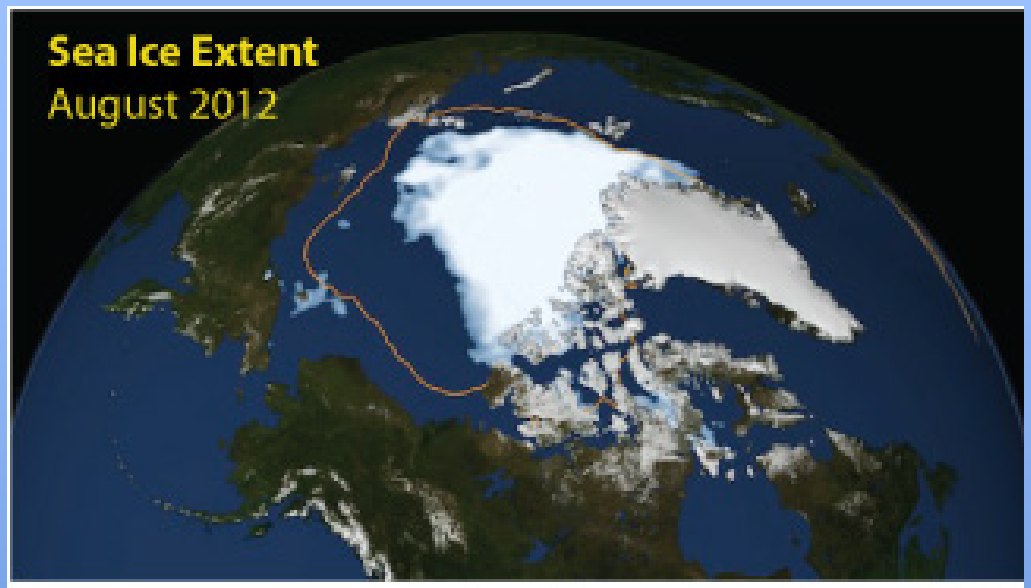
data sources: top: http://www.ldeo.columbia.edu/res/div/ocp/drought/medieval.shtml

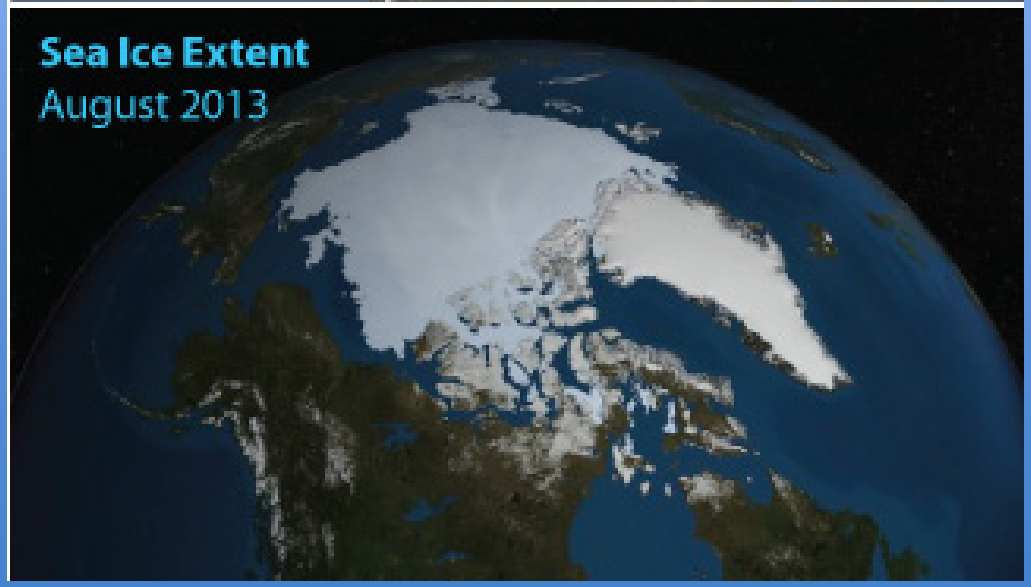
bottom: RS Bradley & JA Eddy, based on JT Houton, et al Climate Change Assessment, Cambridge University Press, Cambridge, 1990 and IPCC 1990 and Mann 1999 and Moburg 2005

Tree rings in North America show that small changes in temperatures result in major changes in precipitation.

Clouds, the debris from large volcanoes, and man-made aerosols can reflect back sunlight and change rainfall patterns.





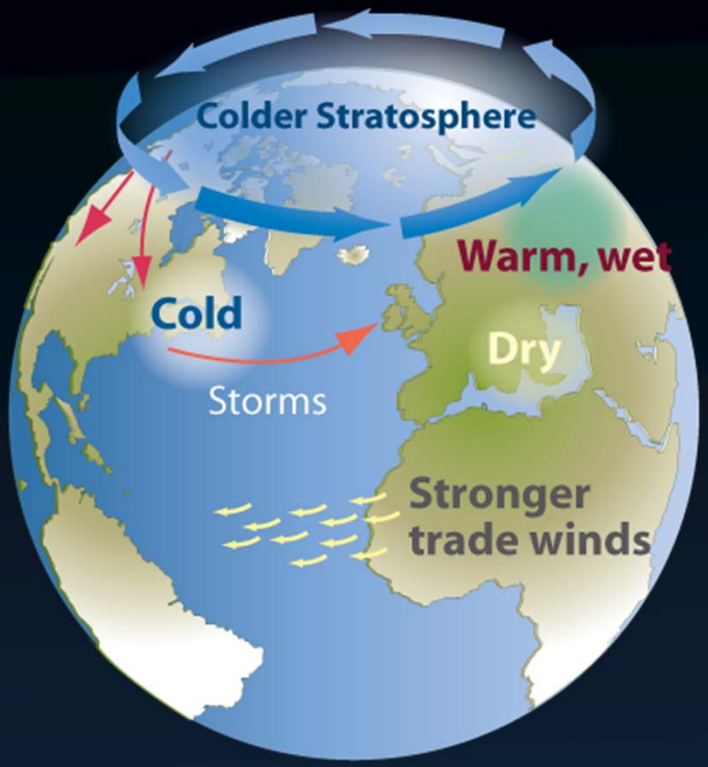


In 2011, large volcanoes erupted in both the North Atlantic and Pacific.

After 2 years of cooling, the summer of 2013 was the coldest ever recorded.

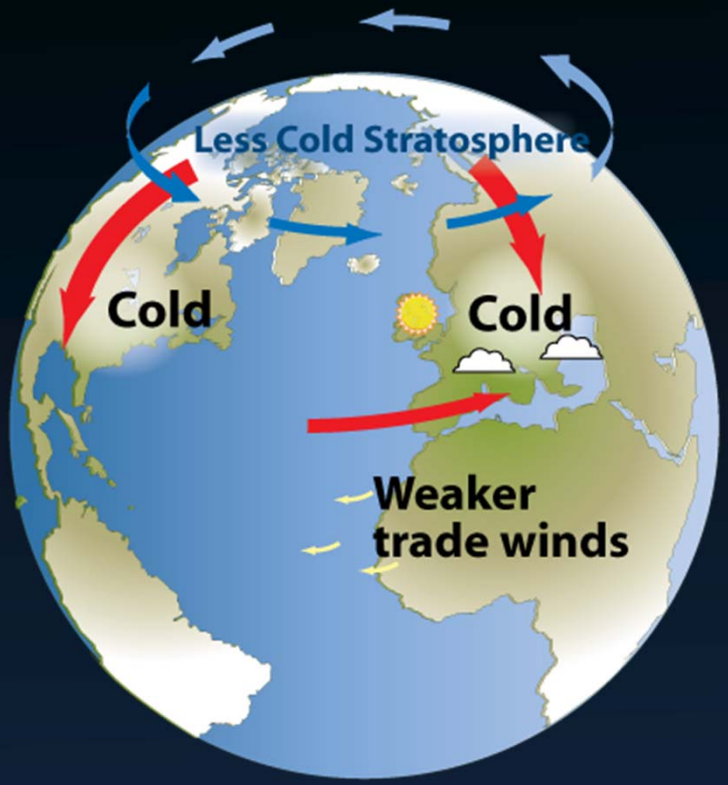
The Arctic sea ice was 60% bigger than 2012 with 920,000 extra square miles after the end of the summer melting season.

courtesy: NASA



Positive AO

In 2012, the impact of northern Atlantic and Pacific volcanoes strengthened the circumpolar winds, making a strong positive Arctic Oscillation and trapping cold air north.



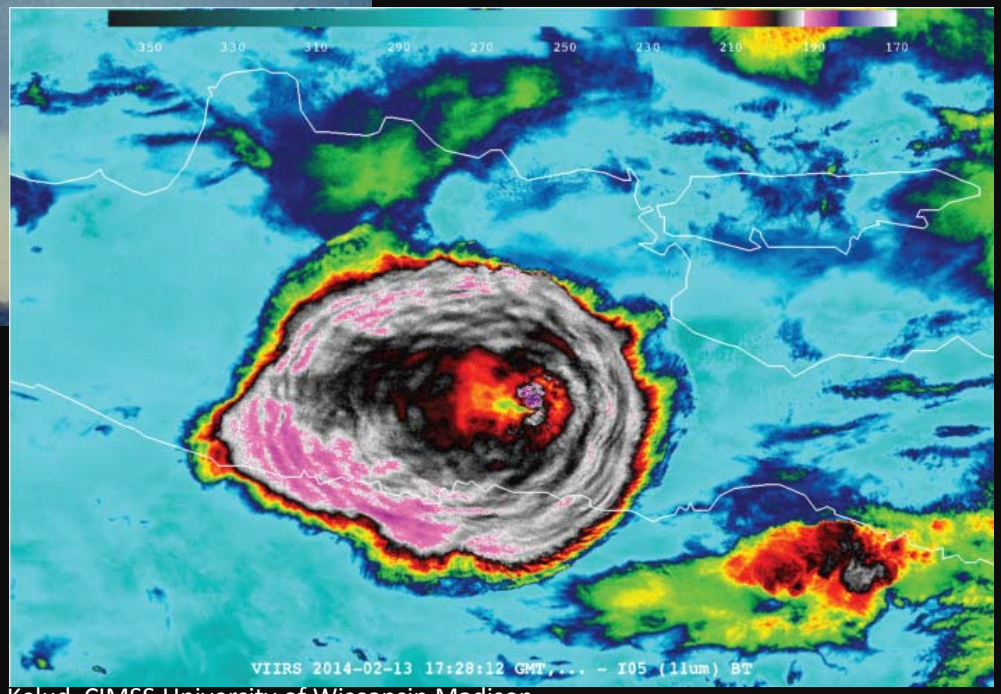
Negative AO

This year the circumpolar winds were weaker and let the unusually cold air flow south.
Result: a cold winter and spring!

Sangiang Api

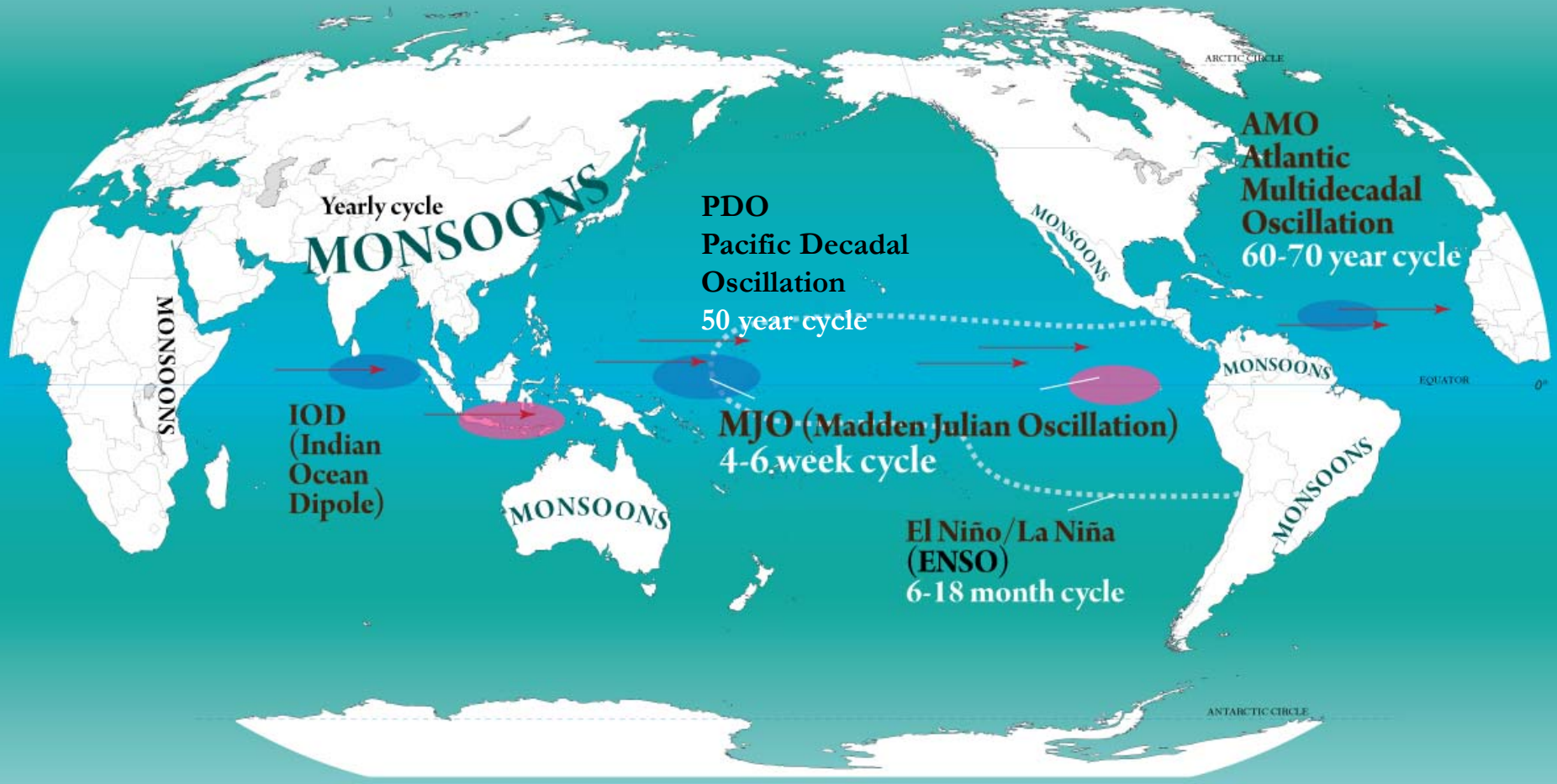
This February and May, Indonesia had volcano eruptions – Mt. Kelud (18.6 miles) and Sangiang Api (12 miles) that were large enough to enter the stratosphere.

Scientists are still studying their potential impact.



Kelud CIMSS University of Wisconsin Madison

Oceans store and transport heat



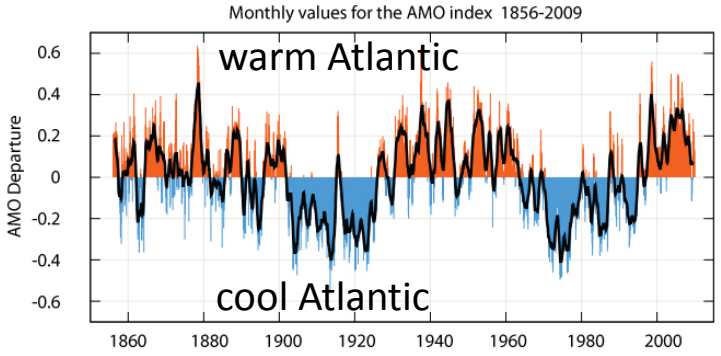
There are several oscillating patterns of ocean currents.

Oceans store and transport heat

The long-term Atlantic Multidecadal Oscillation **(AMO)** turned positive in 1995.

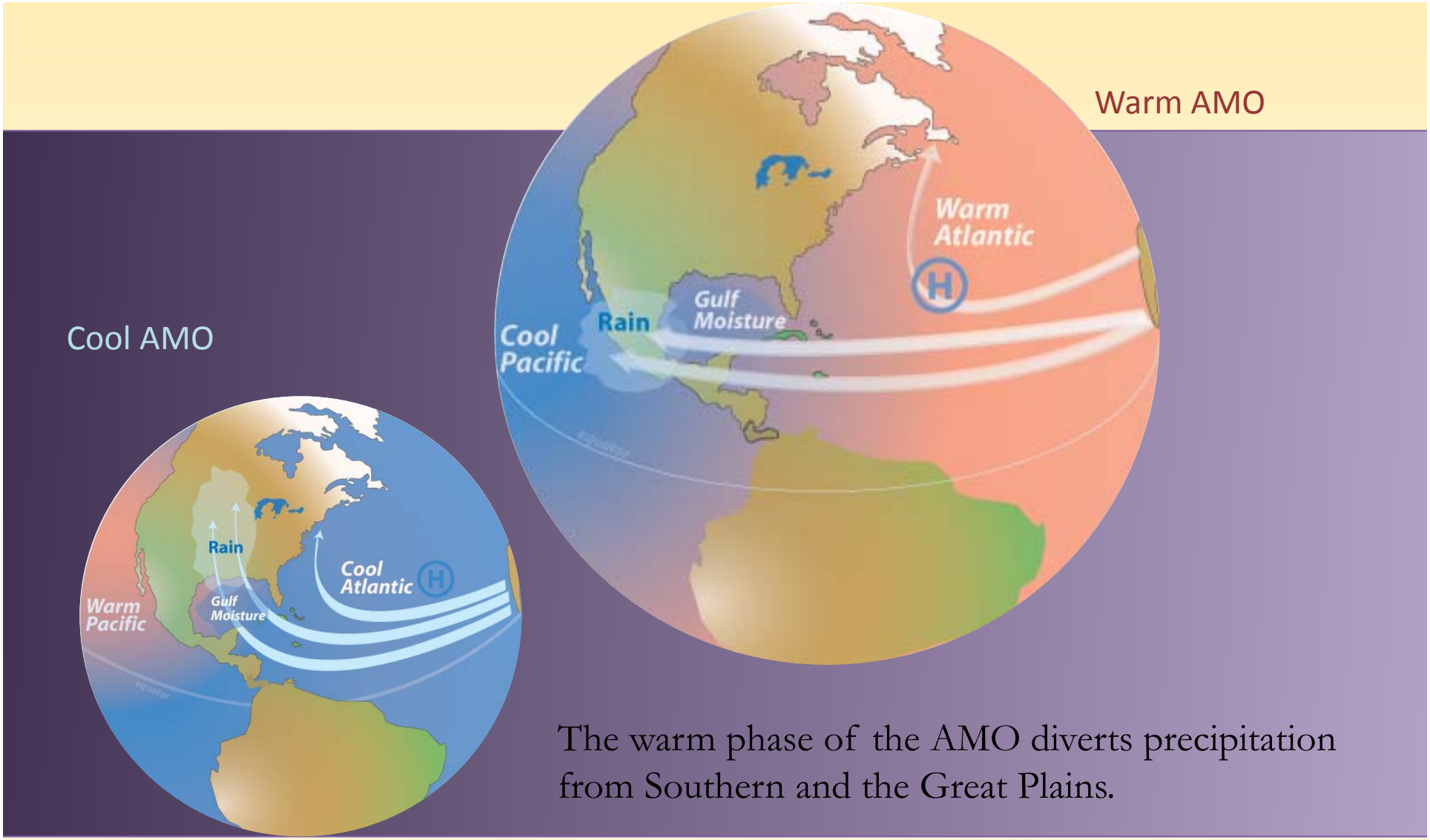
The Gulf stream flows faster.

The North Atlantic warms.



The Atlantic Multidecadal Oscillation (AMO) 1856-2009

http://en.wikipedia.org/wiki/File:Amo_timeseries_1856-present.s



The warm phase of the AMO diverts precipitation from Southern and the Great Plains.

This increases the risk of heat waves, droughts and wildfires in Central, Southern and Midwestern states.

The changing AMO means Oklahoma climate has gone through major climate cycles throughout its history.

In the 1800s, Oklahoma was a cooler and wetter territory. The Indian Relocation Act and Trail of Tears was during the "Little Ice Age".

The land rushes occurred when Oklahoma first showed signs of being warmer and wetter.

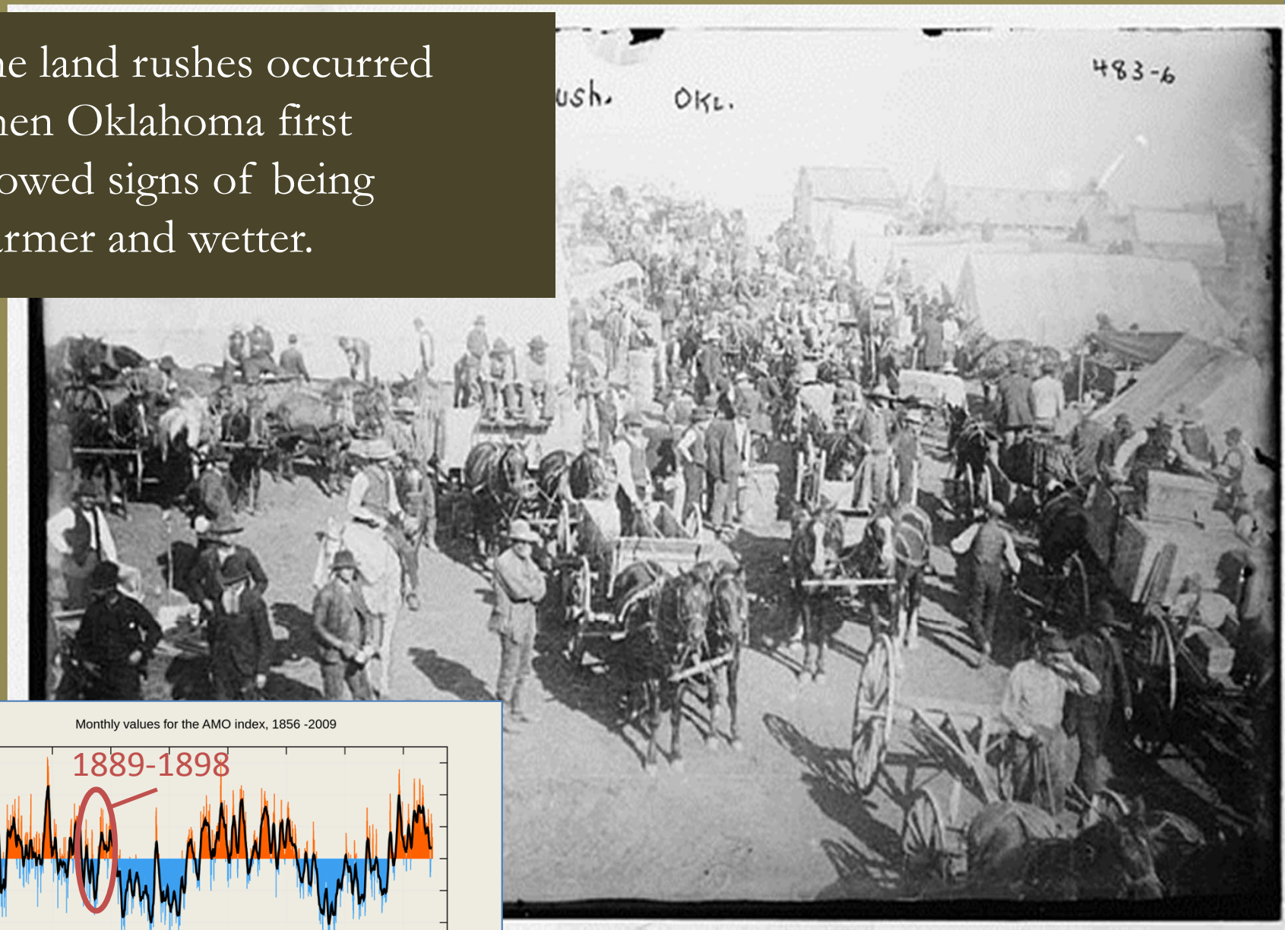
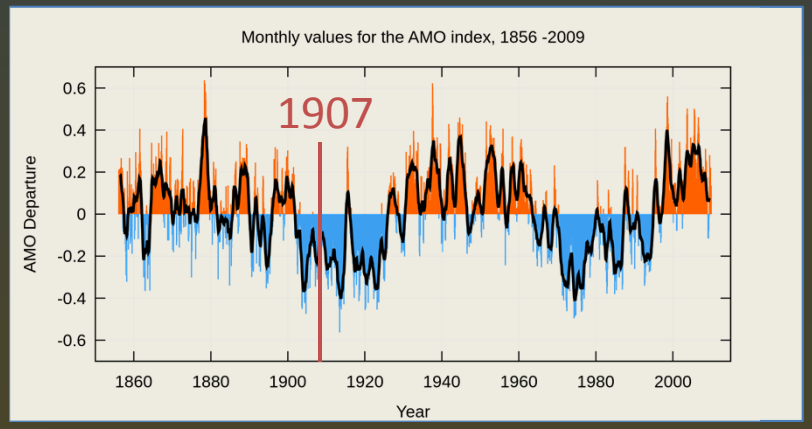


image courtesy: Library of Congress AMO graph http://upload.wikimedia.org/wikipedia/commons/thumb/1/1b/Amo_timeseries_1856-present.svg/2000px-Amo_timeseries_1856-present.svg.png

The AMO was negative and Oklahoma was in a period of plentiful rain and fertility when it became a state.



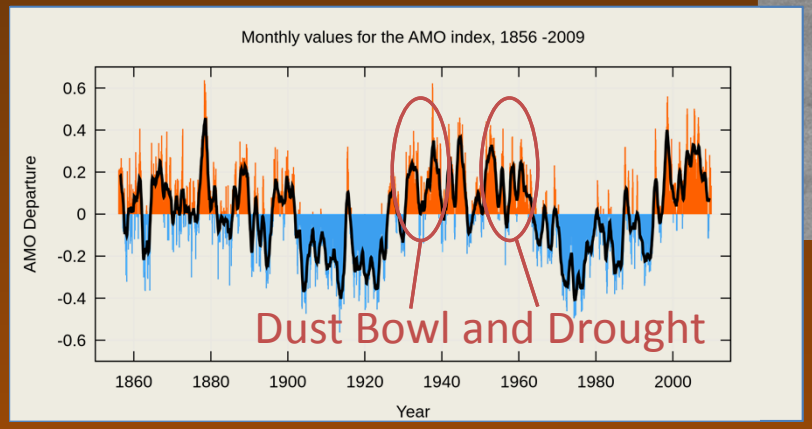
State Capital, Guthrie 1907

image courtesy: Library of Congress AMO graph
http://upload.wikimedia.org/wikipedia/commons/thumb/1/1b/Amo_timeseries_1856-present.svg/2000px-Amo_timeseries_1856-present.svg.png


Dust Storm, Texas 1935

Both the droughts of the 1930s and the 1950s took place when the AMO was positive.


Dust Bowl, Oklahoma 1936



images: http://en.wikipedia.org/wiki/Dust_Bowl AMO graph http://upload.wikimedia.org/wikipedia/commons/thumb/1/1b/Amo_timeseries_1856-present.svg/2000px-Amo_timeseries_1856-present.svg.png

Soil problems were largely ignored and managed by a variety of underfunded projects.

Then on March 21, 1935, Hugh Bennett, Director of the Soil Erosion Service, testified before Congress just as a major dust storm hit Washington DC.

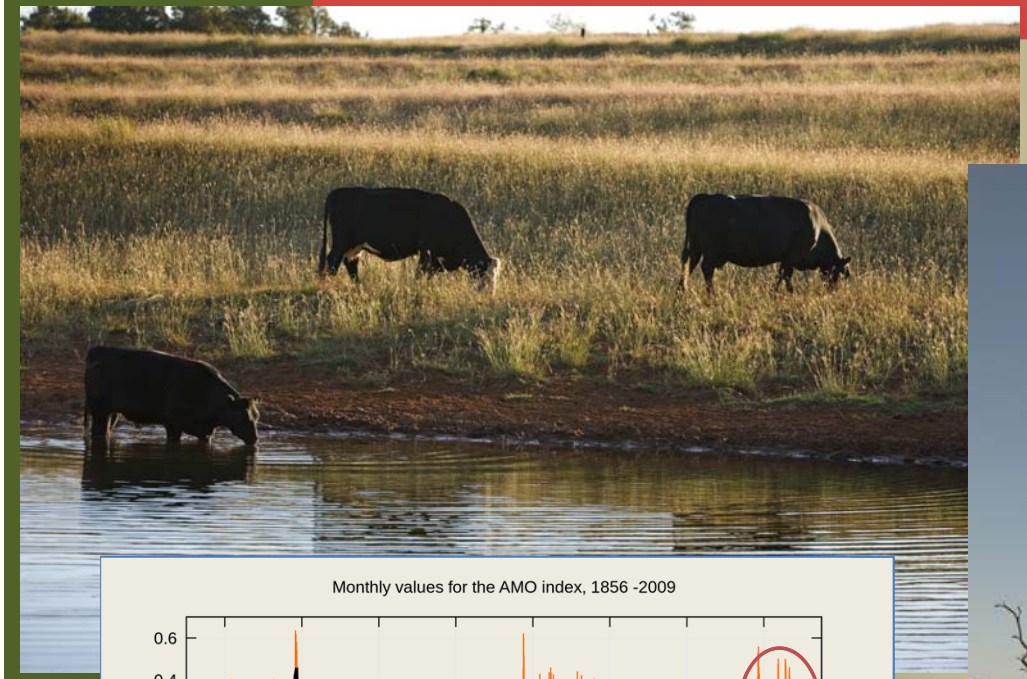
Hugh Bennett

The next day, the Senate passed H.R. 7054 forming the Soil Conservation Service, giving it permanent funding.

Dust storm over the Lincoln Monument: March 21, 1935

From the mid-Seventies through the Nineties,
the AMO was usually negative,
bringing good rains to Oklahoma.

Since then, it is mostly positive, bringing back the conditions that Oklahoma experienced in the 1950s.



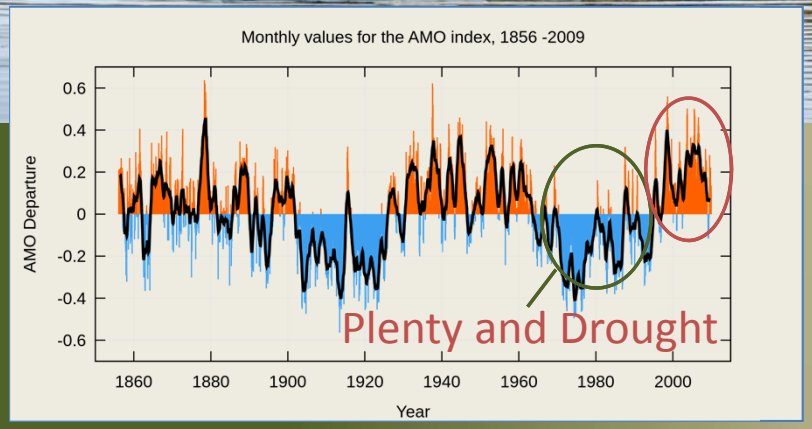
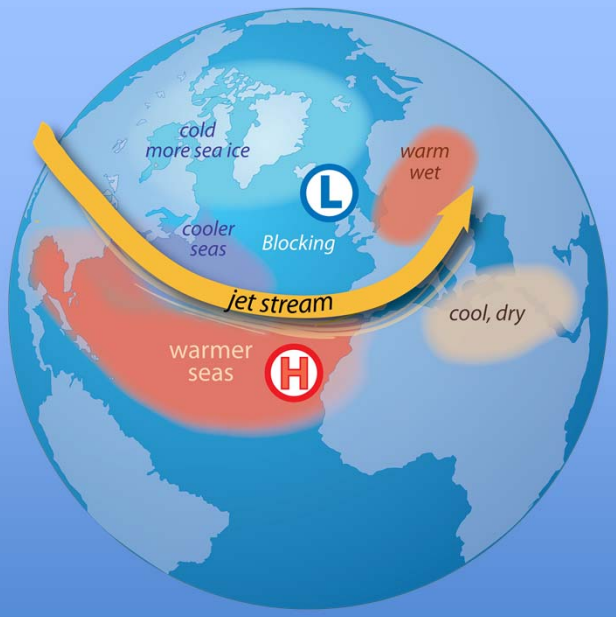


image courtesy of USDA NRCS AMO graph
http://upload.wikimedia.org/wikipedia/commons/thumb/1/1b/Amo_timeseries_1856-present.svg/2000px-Amo_timeseries_1856-present.svg.png

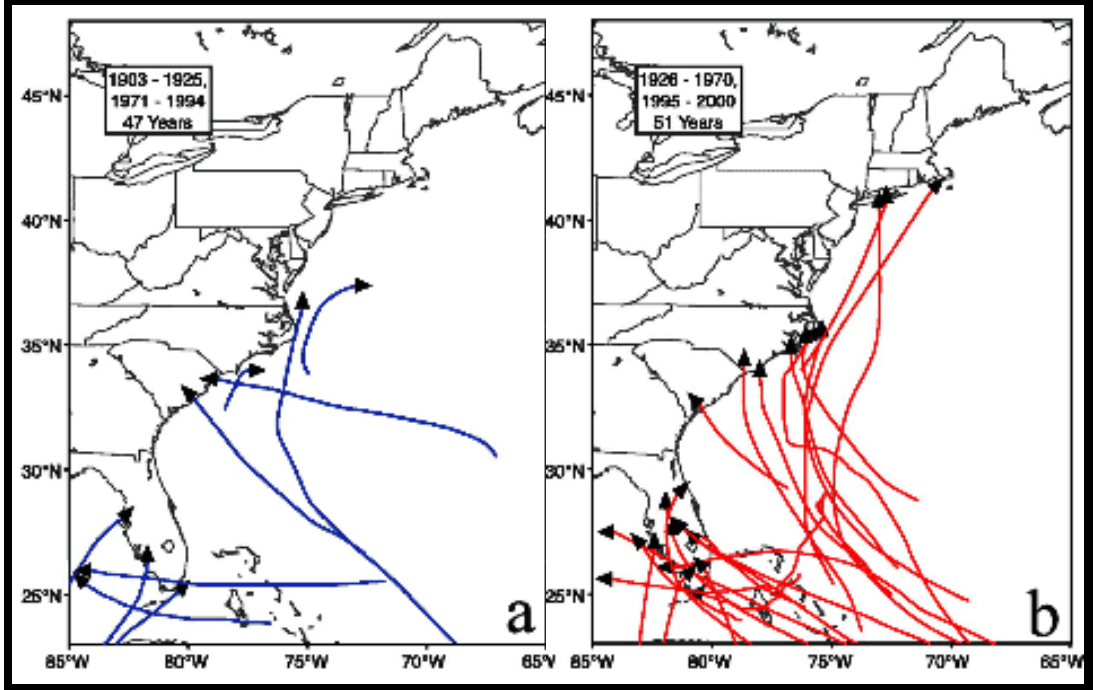
Positive NAO



Negative NAO

When the Atlantic is warm,
winter negative North Atlantic Oscillations
become more frequent.

These warmer AMO temperatures have increased the long-term risk of Atlantic hurricanes.

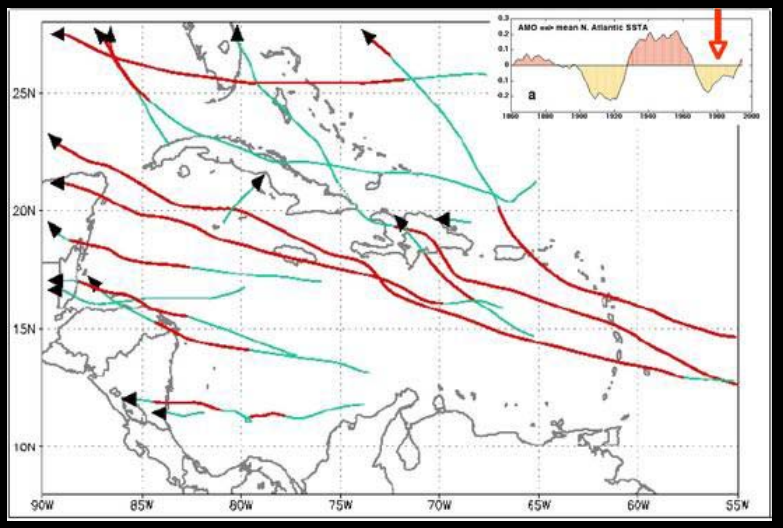


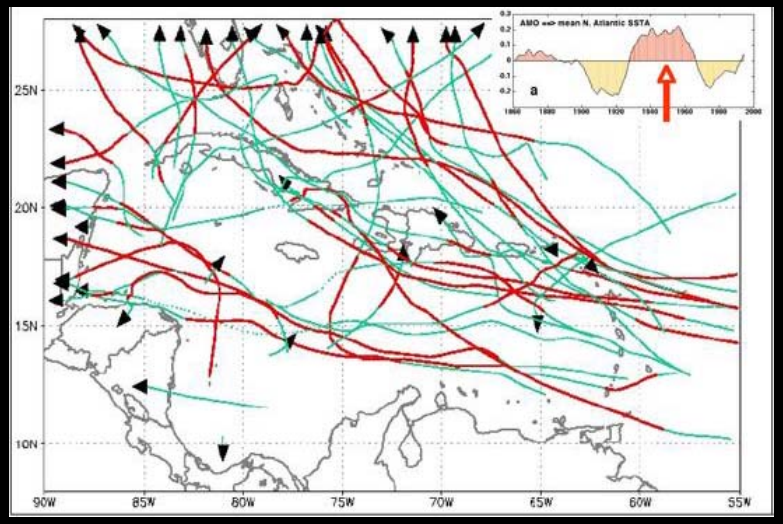
Cool Atlantic

Warm Atlantic

The warm phase of the AMO doubles the number of tropical storms

Cool Atlantic



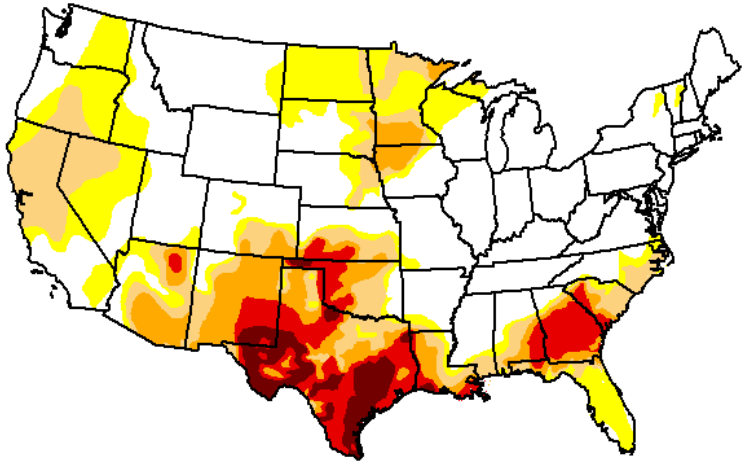


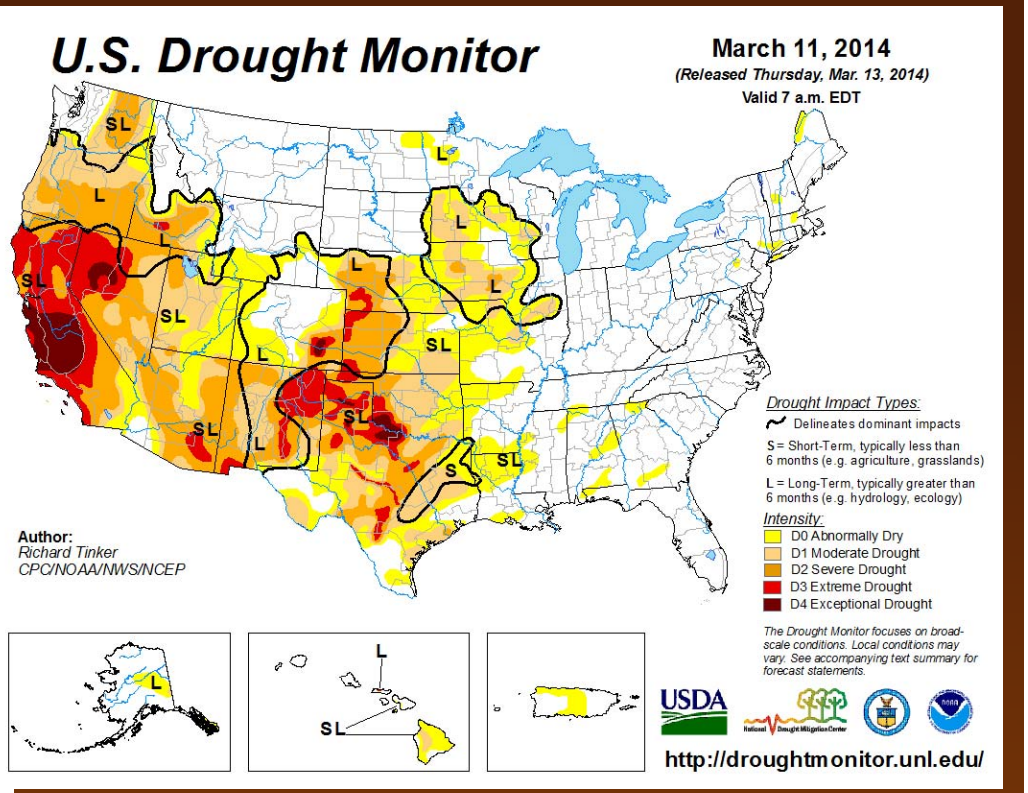
Warm Atlantic

Not all of the US climate problems are due to the changing Atlantic. Changes in the Pacific are creating long-term drought problems in the West.

US Drought Monitor

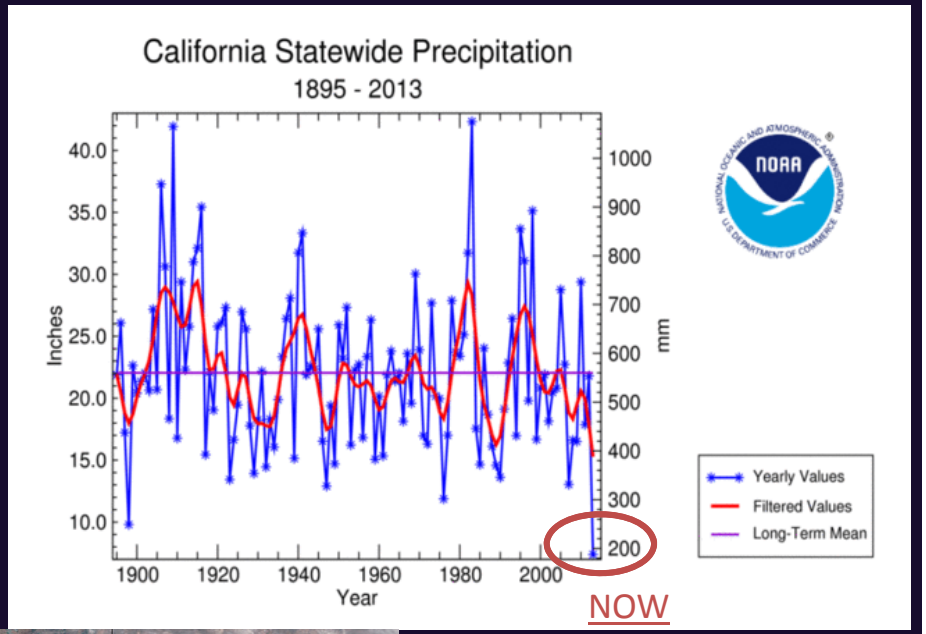
January 3, 2012

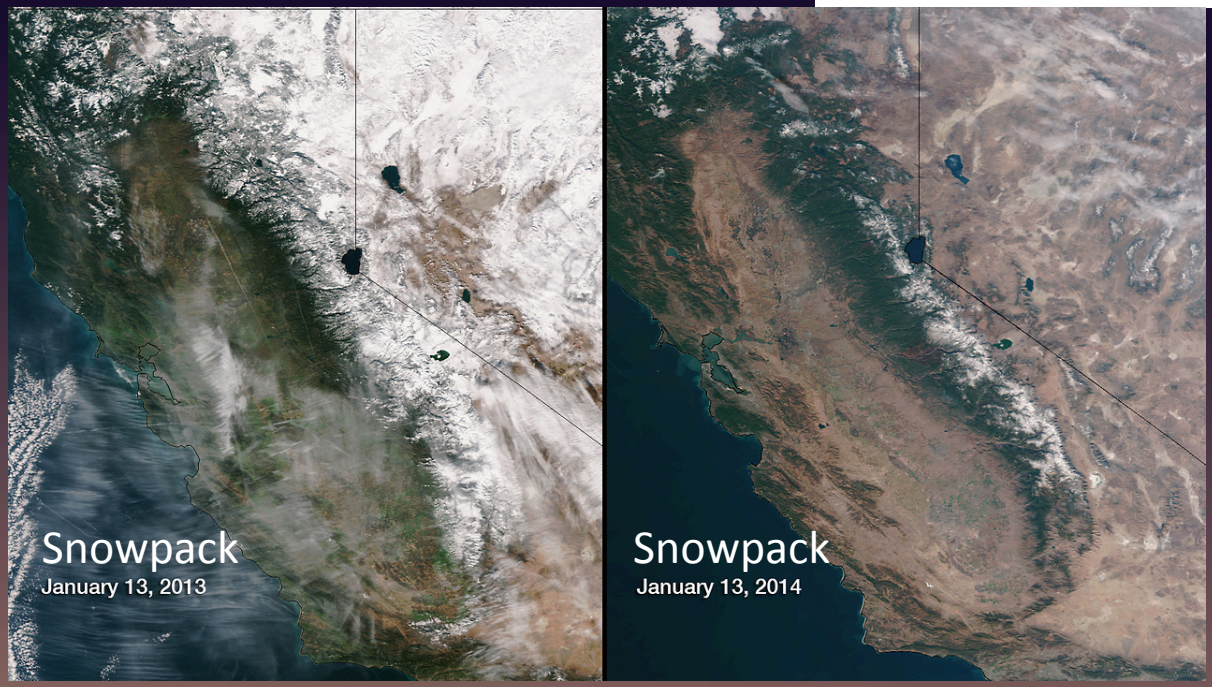




Approximately half of the continental US has been in drought conditions for 2½ years.

In 2013, California experienced
the driest year on record
and Southwestern precipitation
is also low.





above: courtesy National Climate Data Center/ NESDIS/NOAA

left: courtesy NASA

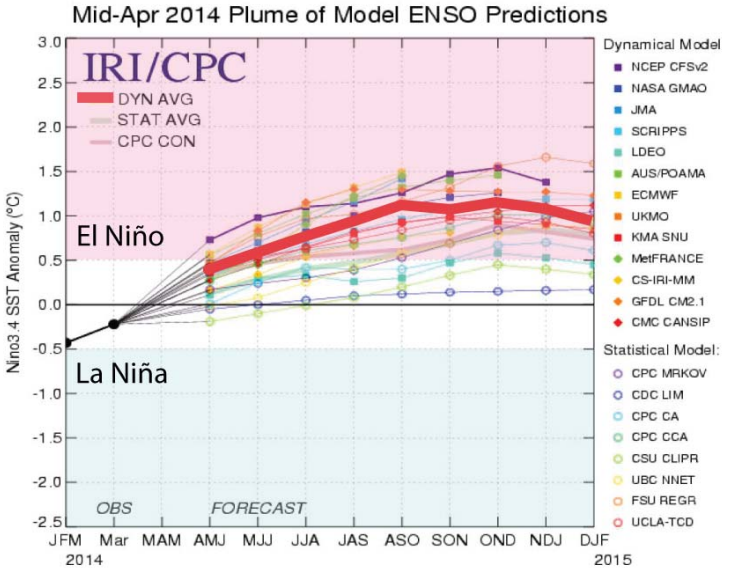
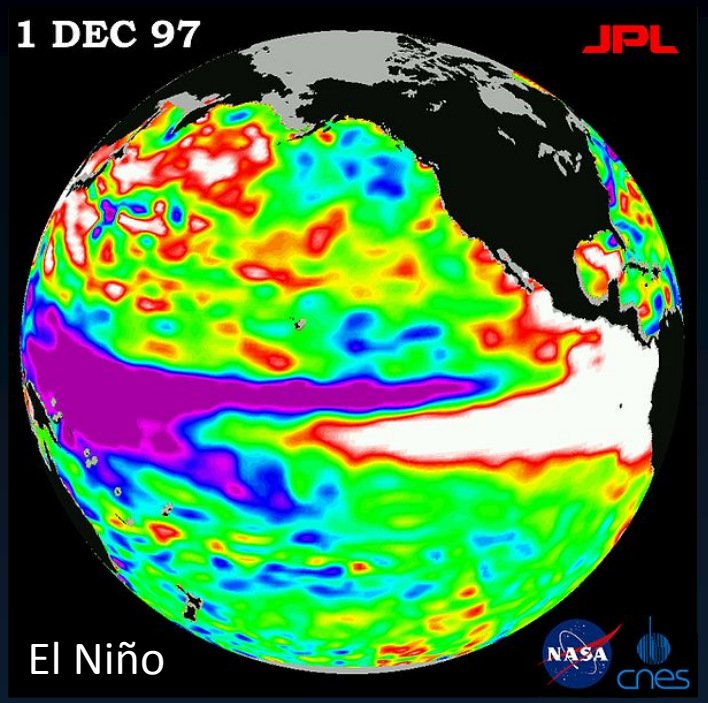


Figure provided by the International Research Institute (IRI) for Climate and Society (updated 16 April 2014).

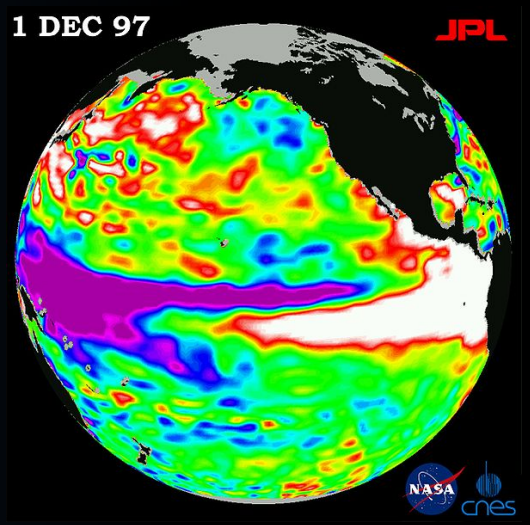


On March 6 NOAA issued an official El Niño watch for this summer.

El Niño conditions developed in the Central and Eastern Tropical Pacific in Late May.

http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/enso_evolution-status-fcsts-web.pdf

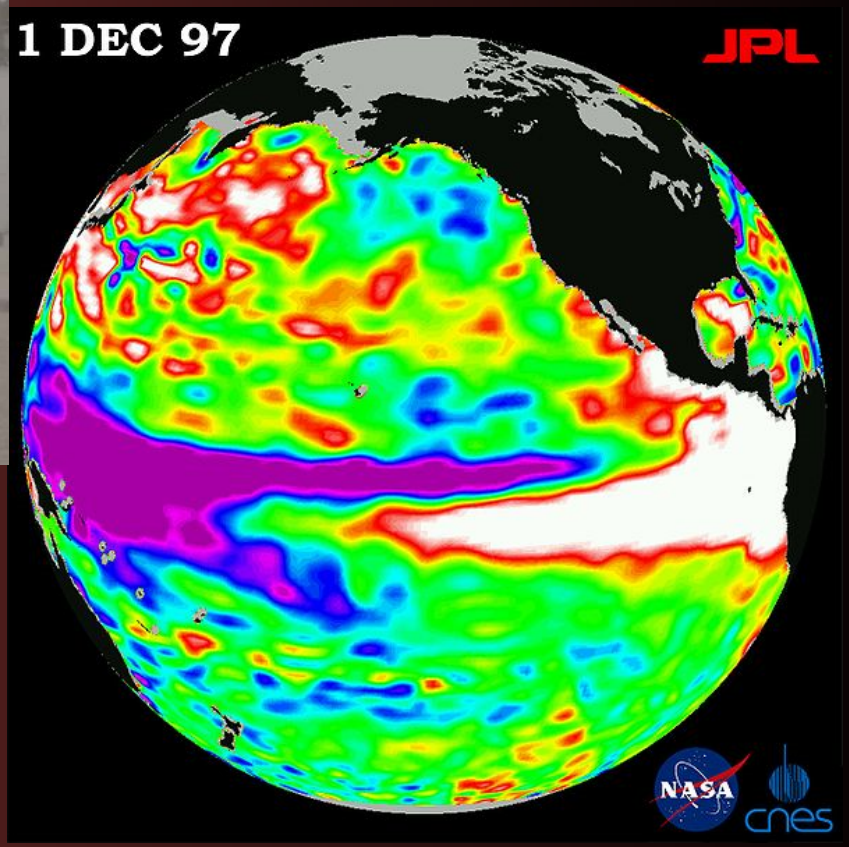
What to monitor as El Niño develops:



LENGTH – If it lasts into winter and spring, it creates warmer weather and severe Nor'easters

SIZE – If it is too small, it will intensify California's drought. A large event will break the drought.

INTENSITY – A hot El Niño creates a warm winter. Cooler events can have cold winters.



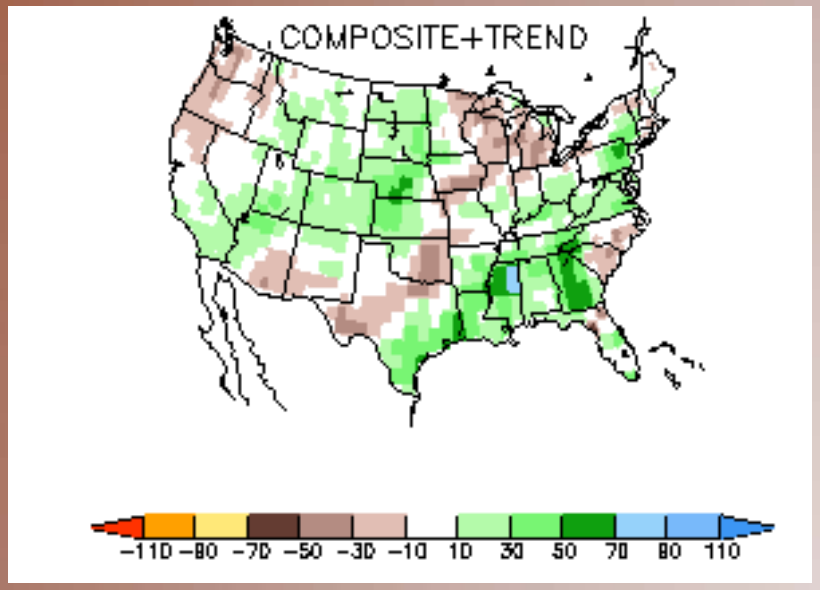
History suggests that large tropical volcanic eruptions enhance El Niño weather patterns.

Cool	Hot	Warm	Dry	Wet
2-4°C or more lower than normal temps.	5°C or more higher than normal temps.	2-4°C or more higher than normal temps.	75% or less of normal moisture	125% or more of normal moisture

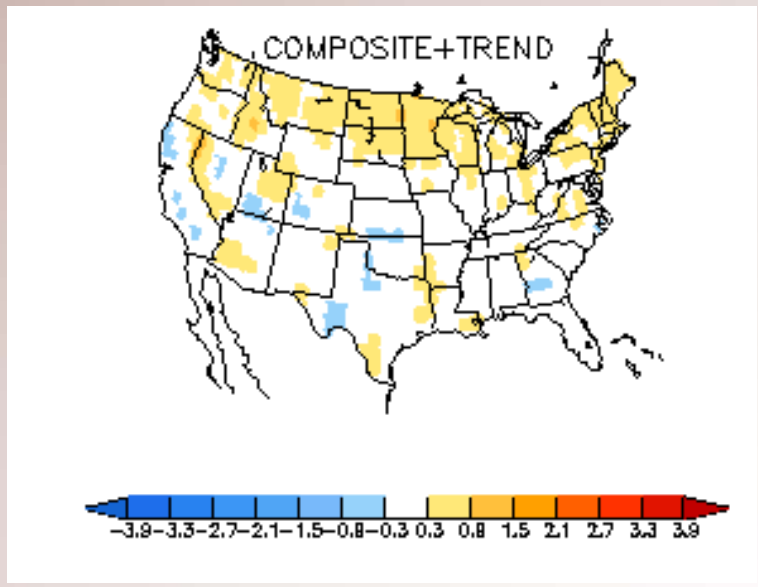
*Pacific volcanic activity may bring more moisture to the Northwest.

If the El Niño conditions become an El Niño, these are the most likely conditions in autumn. The Atlantic Hurricane Season is usually quieter but the Gulf still faces a high risk of strong rainstorms and some flooding.

Precipitation Anomalies



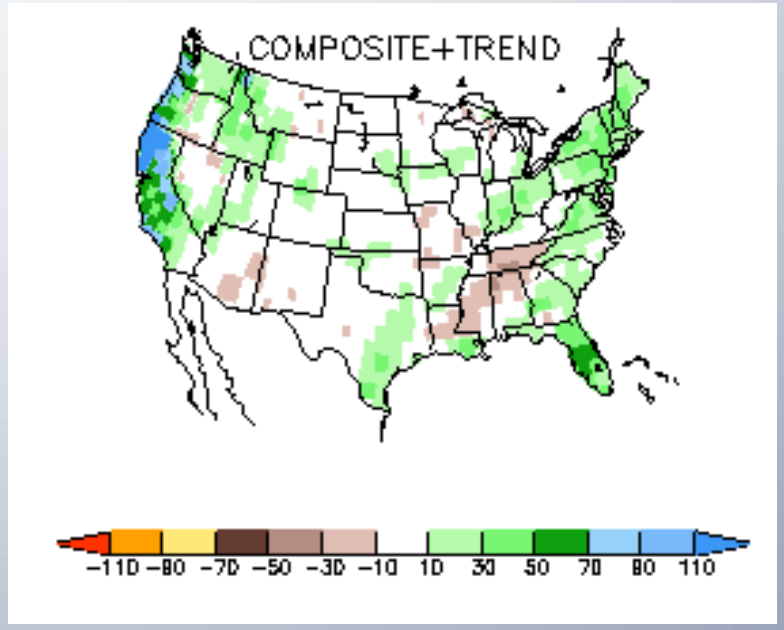
Temperature Anomalies



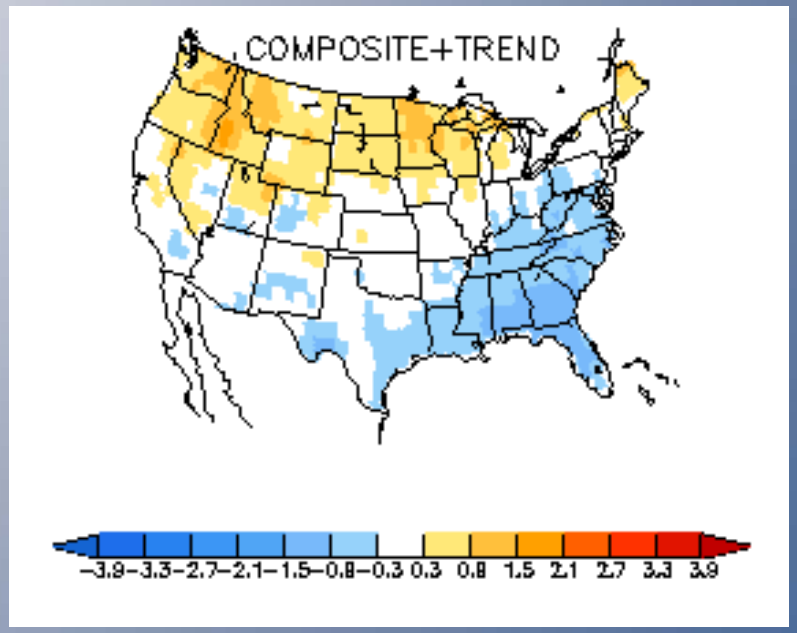
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ENSO/composites/elnino.son.temp.gif
and http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ENSO/composites/elnino.son.precip.gif

If the El Niño conditions become an El Niño,
these are the most likely conditions in winter.
The El Niño brings a higher risk of flooding in California, winter
tornadoes in the South and late winter Nor'easters.

Precipitation Anomalies

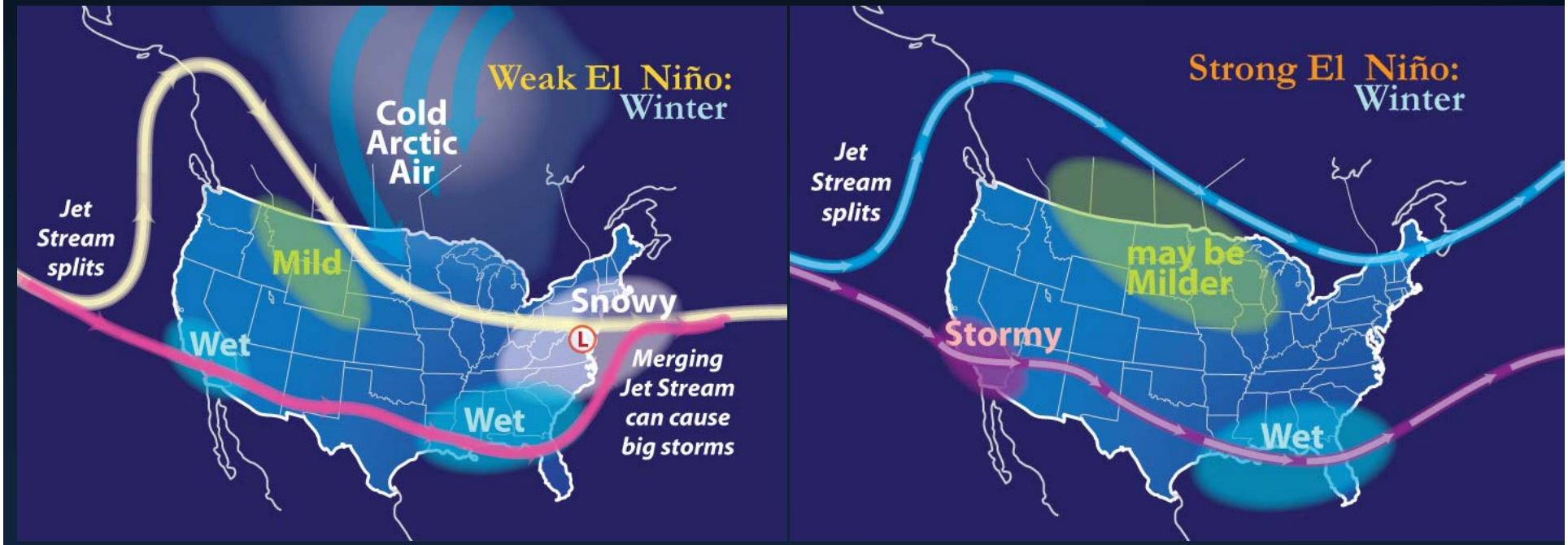


Temperature Anomalies

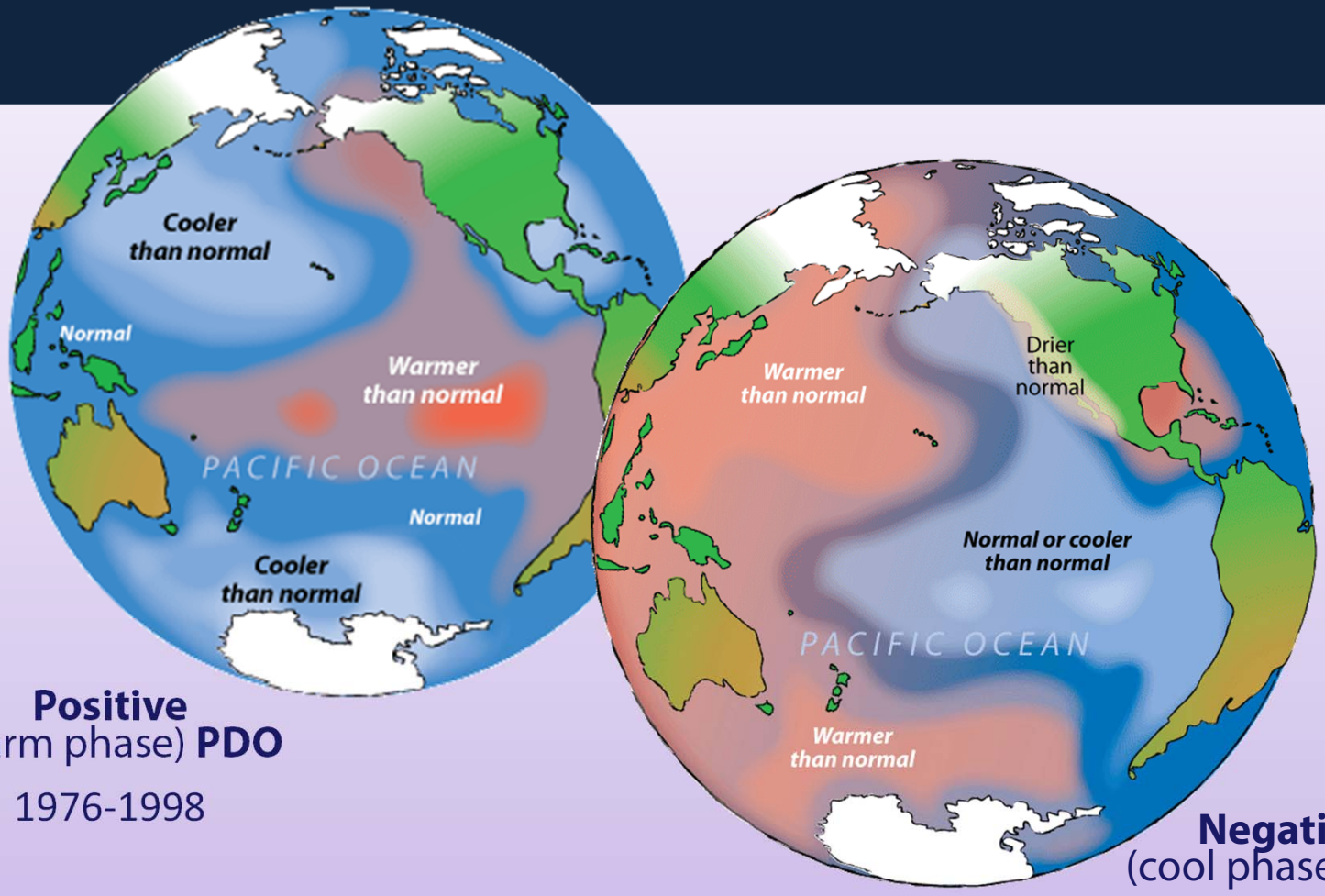


http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ENSO/composites/elnino..djf.temp.gif
and http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ENSO/composites/elnino..djf..precip.gif

Winter and Spring will be shaped
by how big and long lasting the El Nino is.



Like the Atlantic, the Pacific has a long-term cycle,
the Pacific Decadal Oscillation.



Positive
(warm phase) **PDO**
1976-1998

Negative
(cool phase) **PDO**
2006-present

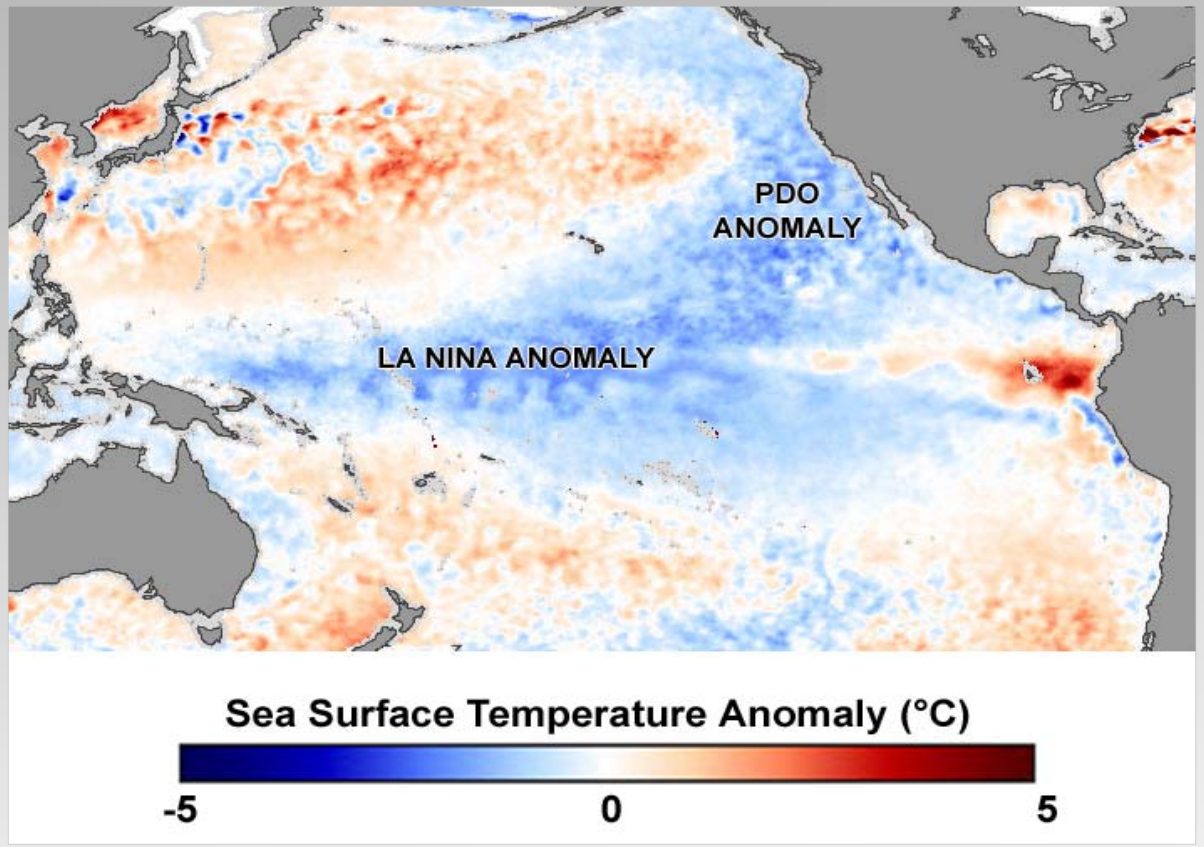
The Pacific Decadal Oscillation
Each phase lasts 20-30 years

© Browning Newsletter

The PDO's impact on precipitation

Winners	Losers
• Midwest US	• California/Southwest US
• *STRONGER MONSOON:* Northern & Central China	• *WEAKER MONSOON:* Southern China
• *STRONGER MONSOON:* India	• *WEAKER MONSOON:* Pakistan
• *STRONGER MONSOON:* Japan	• *WEAKER MONSOON:* North Korea
• Brazil	• Andes Republics/ Southern Argentina
• Southern Africa	• East Africa
• *STRONGER MONSOON:* Eastern Australia	• *WEAKER MONSOON:* Western Australia

A La Niña magnifies the impact of a cold PDO.

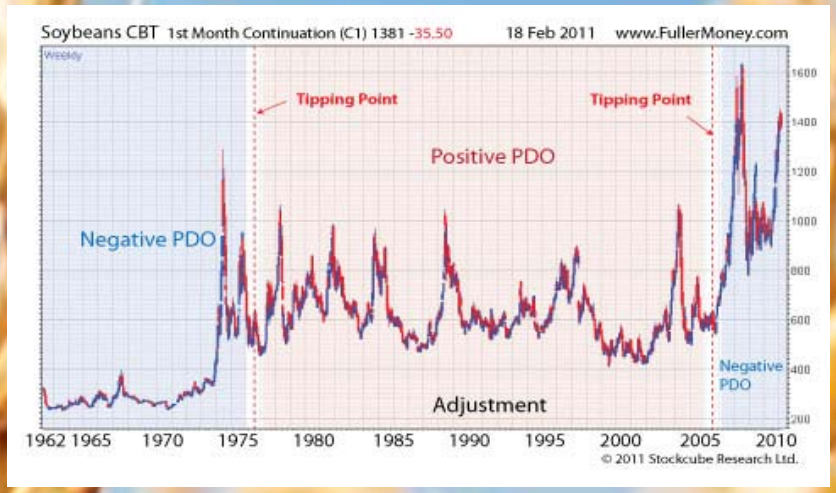


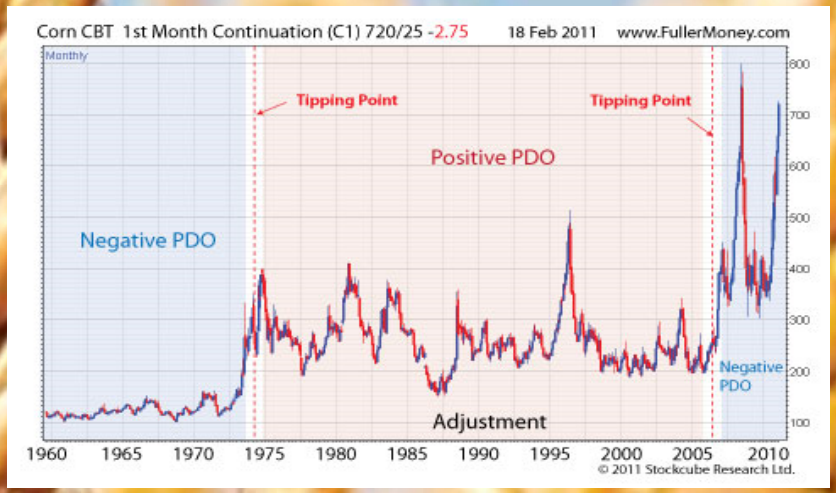
http://en.wikipedia.org/wiki/File:La_Nina_and_Pacific_Decadal_Anomalies_-_April_2008.png

The impact on agriculture

Wheat 1960-2011

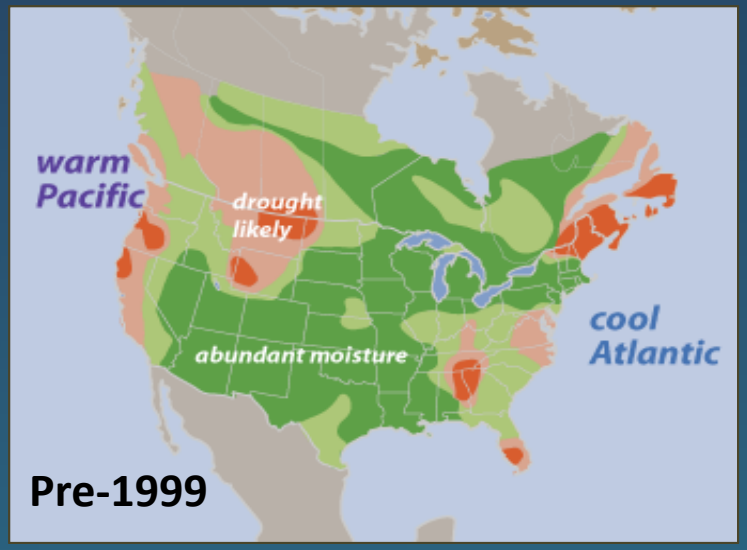
Soybeans 1962-2011



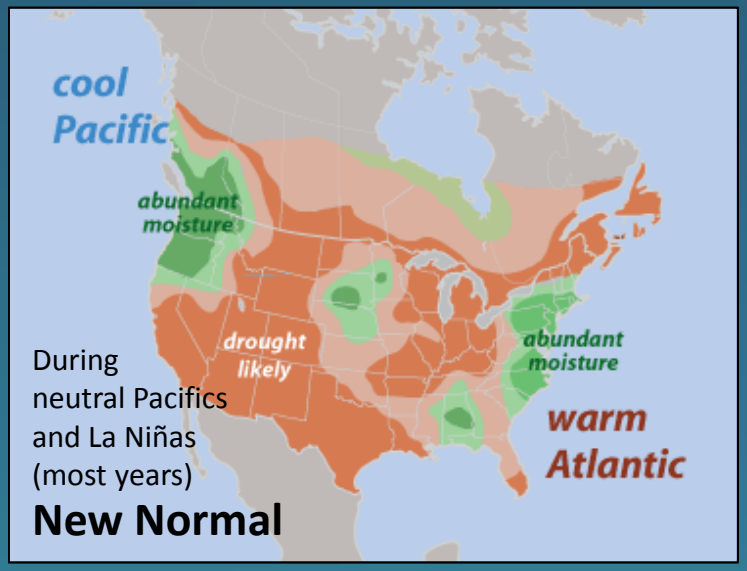


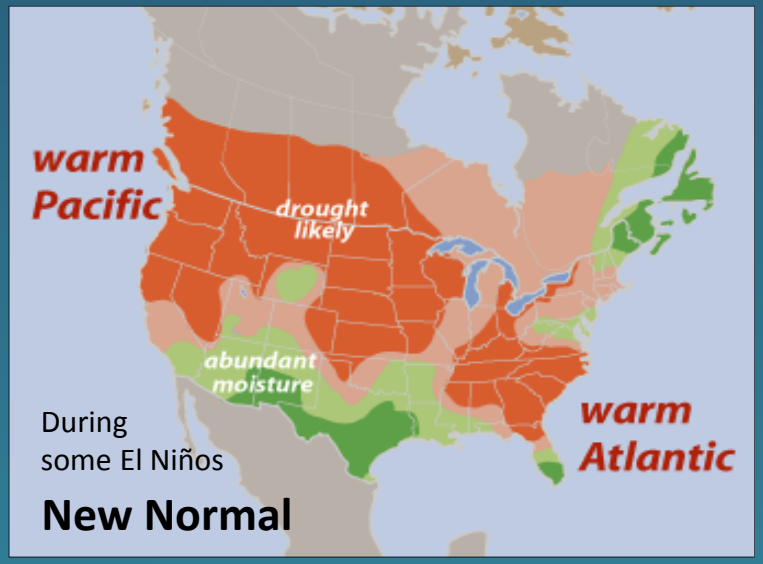
Corn 1960-2011

Since 2006, the two oceans have combined to create dry weather in the West and Great Plains



From the mid 1970s to the late 1990s the USA & Canada enjoyed the most benign combination of the PDO and AMO.





As the east Pacific changes from cool to warm and back again, drought hits much of the nation for months, even years at a time.

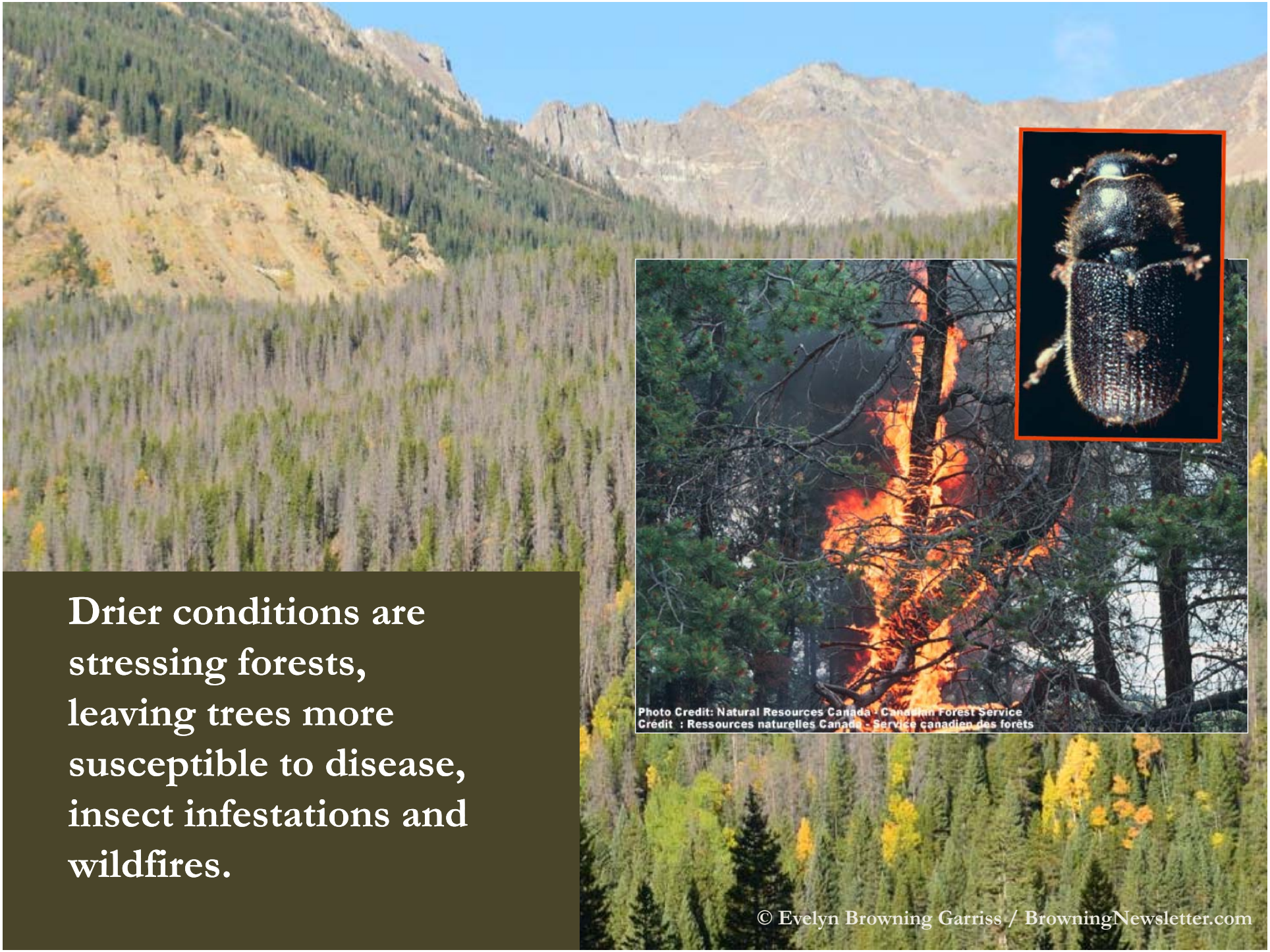
data-US only: US Geological Survey

Bitterroot National Forest

1909 1948 1989

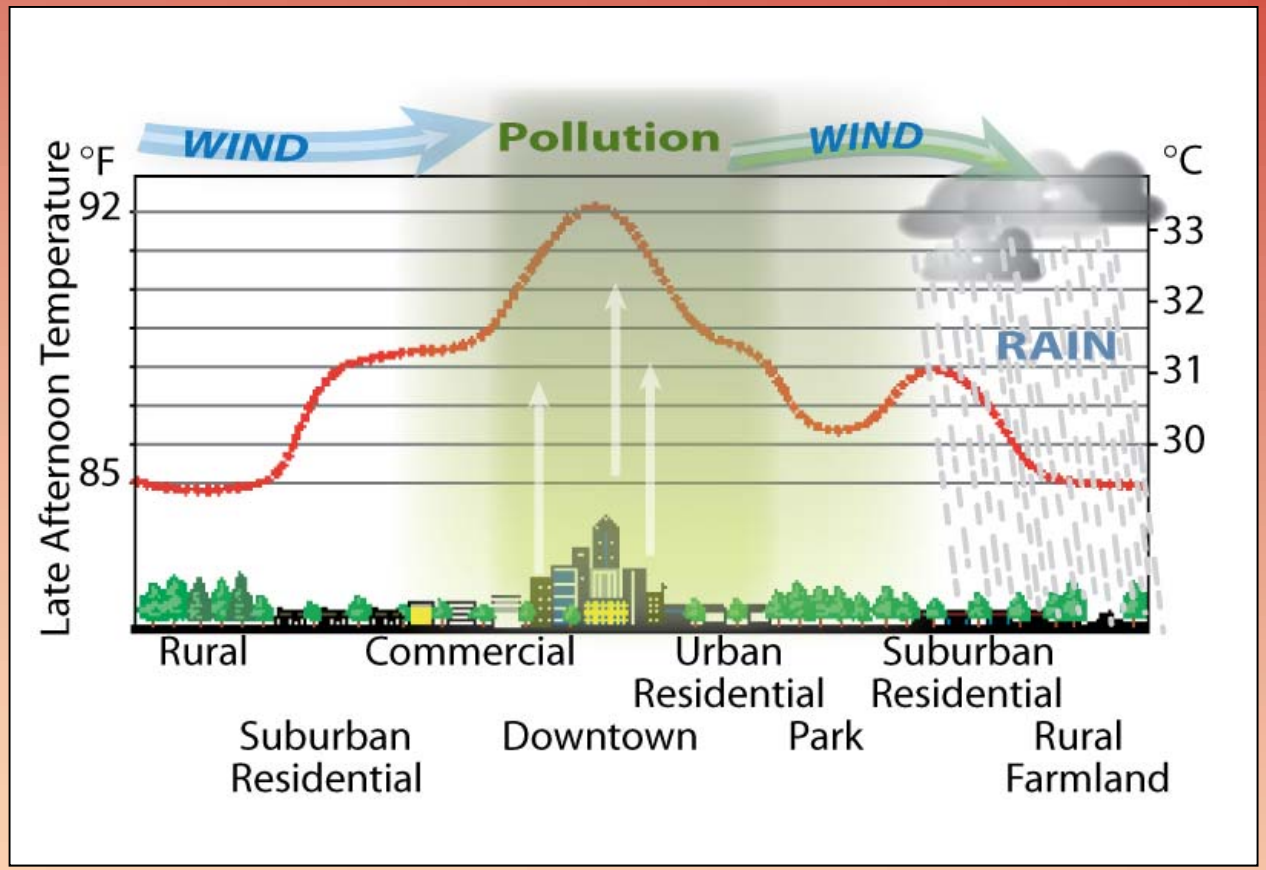
Between fire suppression policies and decades of warm PDO precipitation, Western forests have become too dense for today's drier conditions.

http://upload.wikimedia.org/wikipedia/commons/e/ea/Forest_Development_in_Bitterroot.jpg

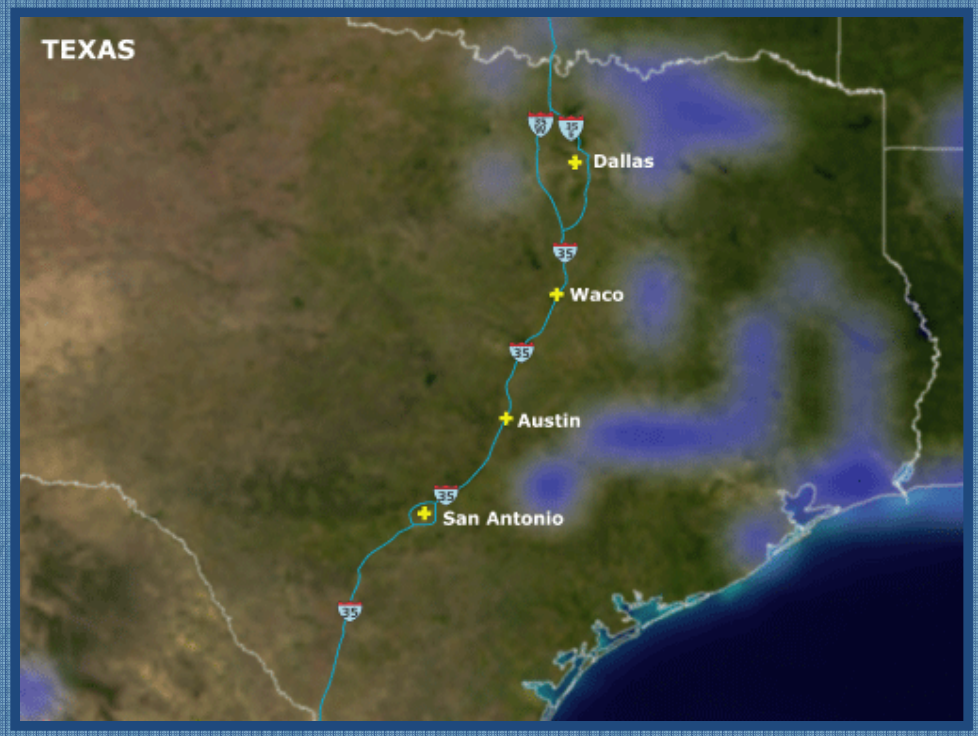


Drier conditions are stressing forests, leaving trees more susceptible to disease, insect infestations and wildfires.

Human construction, pollution, and energy use makes the climate change even more extreme.



http://eetd.lbl.gov/HeatIsland/HighTemps



The mean monthly rainfall rates within 30-60 km *(18-36 miles)* downwind of the cities averaged 28% greater than the upwind region.

In some cities, the downwind rainfall was as high as 51% greater.

source: Dr. J. Marshall, et al. http://www.gsfc.nasa.gov/topstory/20020613urbanrain.html

Conclusions

- **Climate change is not linear. It ebbs and flows.**

- **Because of the recent Polar eruptions, there was a cooler, stormier Midwestern and Eastern winter and spring and a volatile early summer. Drought should increase in California. Two large equatorial volcano eruptions will shape the next 3 years.**

- **The warm phase of the AMO has created hotter summers, and stormier winters, springs and hurricane seasons. This is increasing the risk of flood contamination and erosion east of the Rockies.**

- **There is an 80% chance of summertime El Niño conditions and a 65%+ chance of it lasting through winter into next spring. Historically, this means a quieter Atlantic hurricane season, a milder winter in the north and stormier winter in California and the southern tier of states.**

- **We have reached a tipping point. The PDO has changed and is creating more extreme weather and severe Western and Great Plains droughts.**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