

An aerial photograph of a rural landscape featuring rolling hills, patchwork fields, and a small farmstead with silos and barns. The image is overlaid with a semi-transparent green rectangular box that serves as a background for the text.

# Changing Climate: Impacts on Agriculture

Great Lakes Crop Summit 2015

© 2015 Evelyn Browning Garriss



# Conclusions

- **Climate change is not linear. It ebbs and flows.**
- Recent polar volcano eruptions created a cool autumn and will create a cold winter and cooler early spring. The impact of the volcanoes should fade during springtime and should have limited impact on the growing season.
- The warm phase of the AMO usually creates hotter summers (except during summers with major volcanic cooling) and stormier spring and summers around the Great Lakes and Corn Belt.  
**The effect should last another 15 – 20 years.**
- There were early summertime El Niño conditions and the conditions should affect this winter as well. Historically this means slightly cooler and wetter conditions in winter and, if it lasts until spring, creates a warm spring planting season with good rainfall in the Western Corn Belt.
- We have reached a tipping point. The PDO has changed and is creating more extreme weather and an increased risk of dry weather around the Great Lakes and Eastern Corn Belt for the next 15 – 20 years. It may also have changed the impact of El Niños.



# 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)



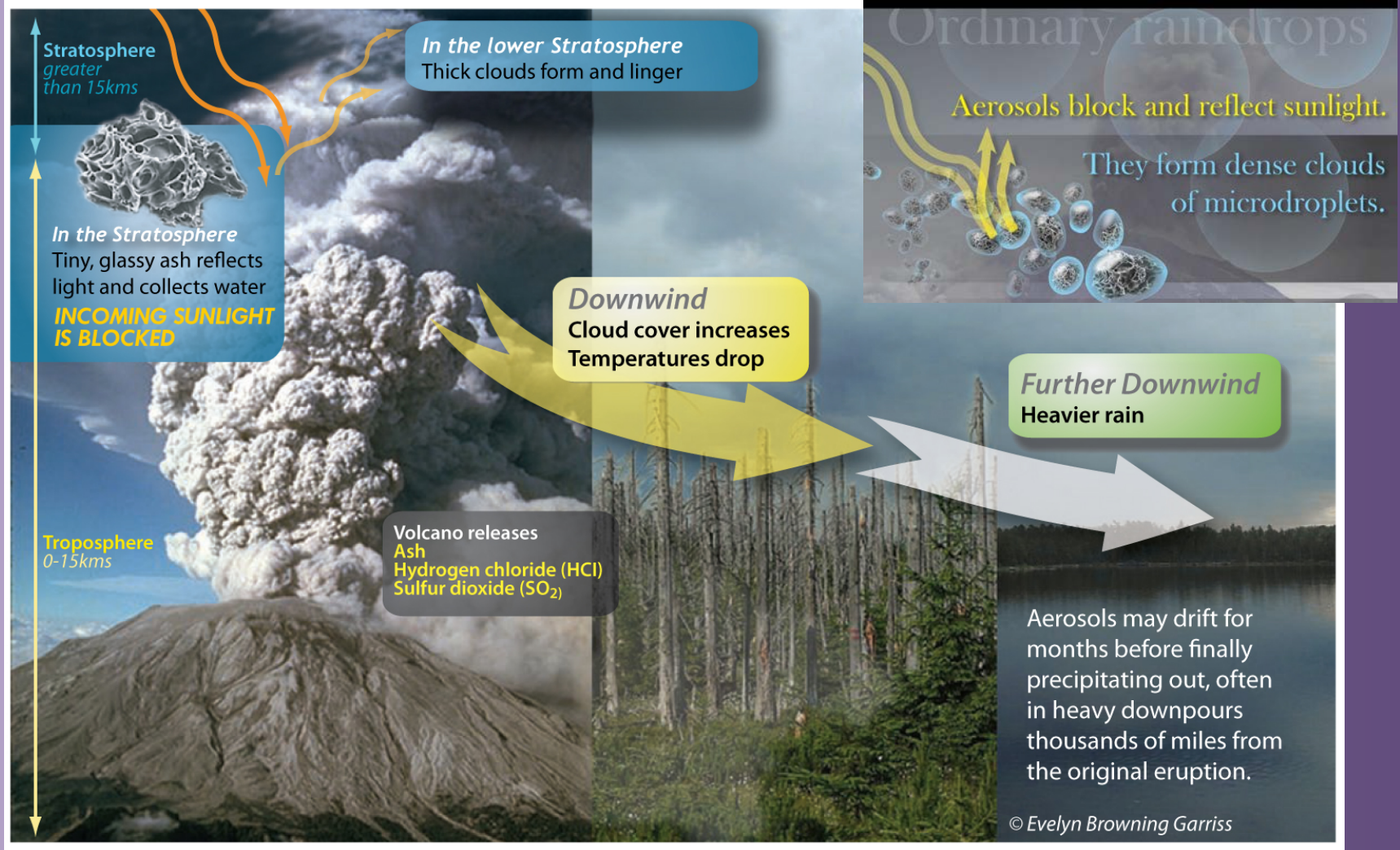
As an historical climatologist,  
I look at what factors are shaping the weather and use:



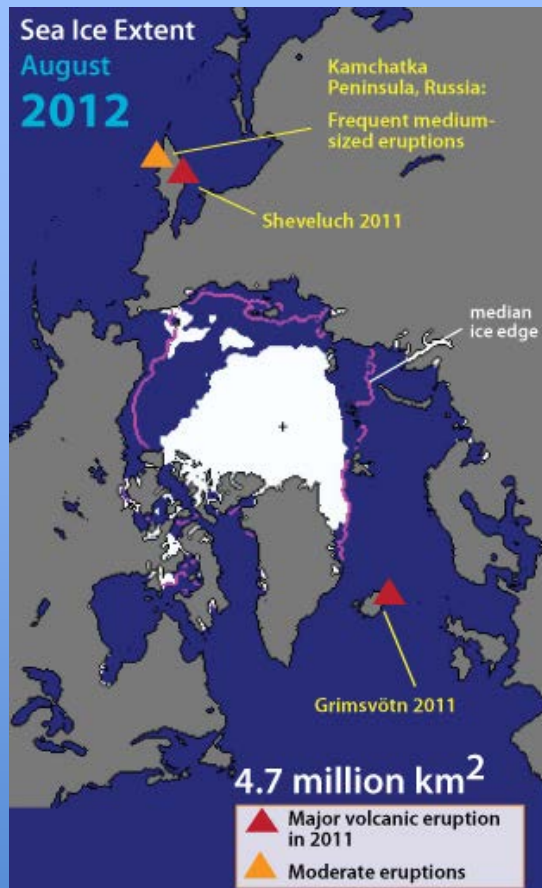
Historical records, coral and tree rings,  
sediment layers, and glacial cores to learn how they  
shaped the weather in the past.



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



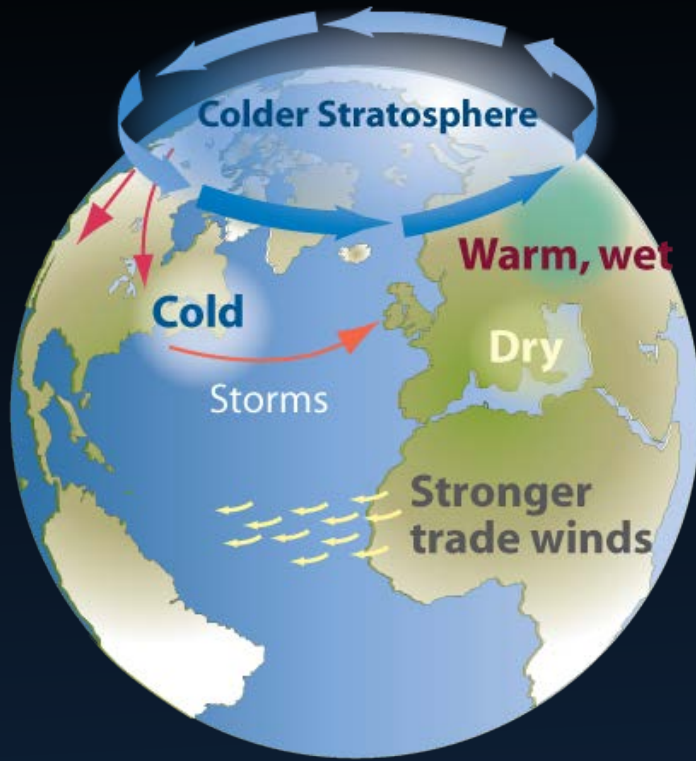
In 2011, large volcanoes erupted in both the North Atlantic and Pacific.



The cool Arctic summers have reduced the amount of summer melt for three years in a row.

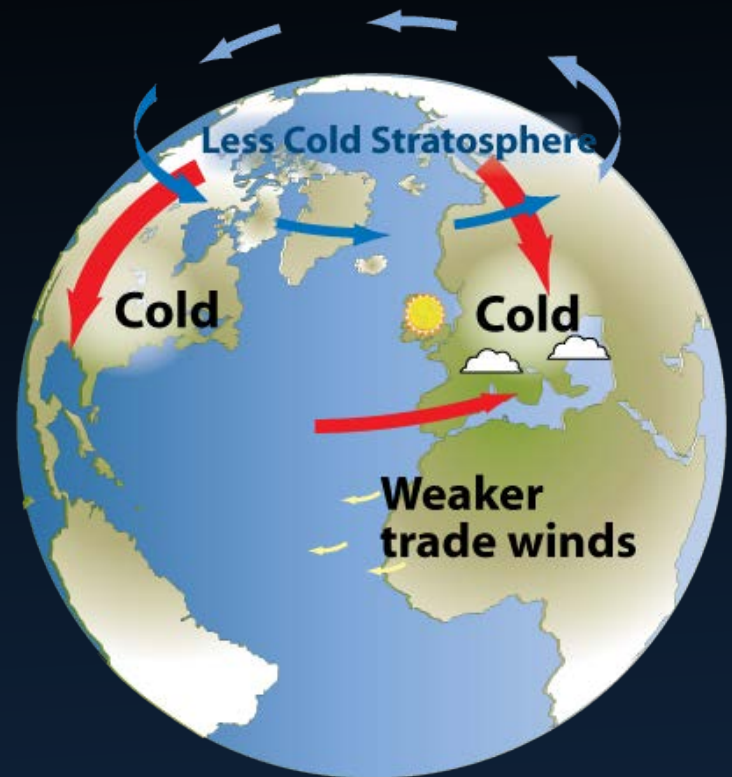






## Positive AO

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 are weaker and are letting the unusually cold air flow south.

## Facts to Remember about Volcanoes and Climate

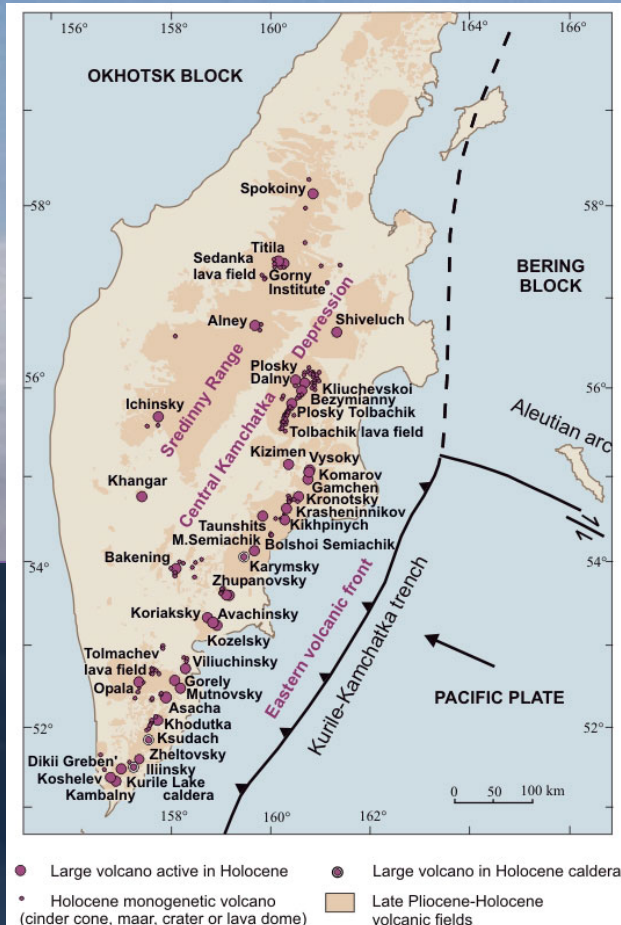
1 Volcanoes are the **WILD CARDS** of climate. They **temporarily** change long-term trends.

2 The key to an explosion's impact is **LOCATION, LOCATION, LOCATION!** Explosions in different areas change wind patterns differently.

The Russian volcanoes are restless and even moderate eruptions encourage the eastward – flowing polar jetstream to dive furthest south in North America.

**Expect this to happen several times this winter.**

<http://www.kscnet.ru/ivs/volcanoes/holocene/main/main.htm>





## News Notes

**■** If the chemical haze from the giant eruption in Iceland's Hekla volcano field has its normal historical impact, it could create energy problems for Europe this heating season. Not only does this type of eruption historically produce ash and weather increasing demand, but it creates haze that affects solar energy. It produces heavy clouds, which interfere with solar energy and acidic rain which can be damaging to the exposed elements of wind generators.

**■** A recently released European Energy Markets Observatory report has warned that the risk of blackouts in Europe will grow in the coming winter as thermal power generating capacity has been shuttered amid the regional economic slump and a greater reliance (23.5%) on renewables.

A cold winter would exacerbate the problem. The report noted growing share of renewable energy is pushing out conventional sources of power, reducing the "flexibility" system's margin to meet peak demand in specific conditions such as cold, dark and windless days.

In particular, the study noted that 3 nuclear reactors in Belgium have been killed because of damage and safety concerns. France usually relies on Belgian power imports on cold days because of the relatively large number of homes in the larger country that are equipped with electric heating.


Add to this the growing difficulties with Russia over the Ukraine. Russia's Gazprom is a major provider of gas and has threatened to cut supplies as a negotiation tool in the past.


**■** Great Britain's National Grid has warned that a seven-year low in gas supplies this winter will be a seven-year high in gas prices. The company's report says that its spare capacity is currently at 4%, compared to 17% three years ago. Since then, 15 power plants have been closed or partially closed, taking over a large chunk of the UK's energy-generating capacity.

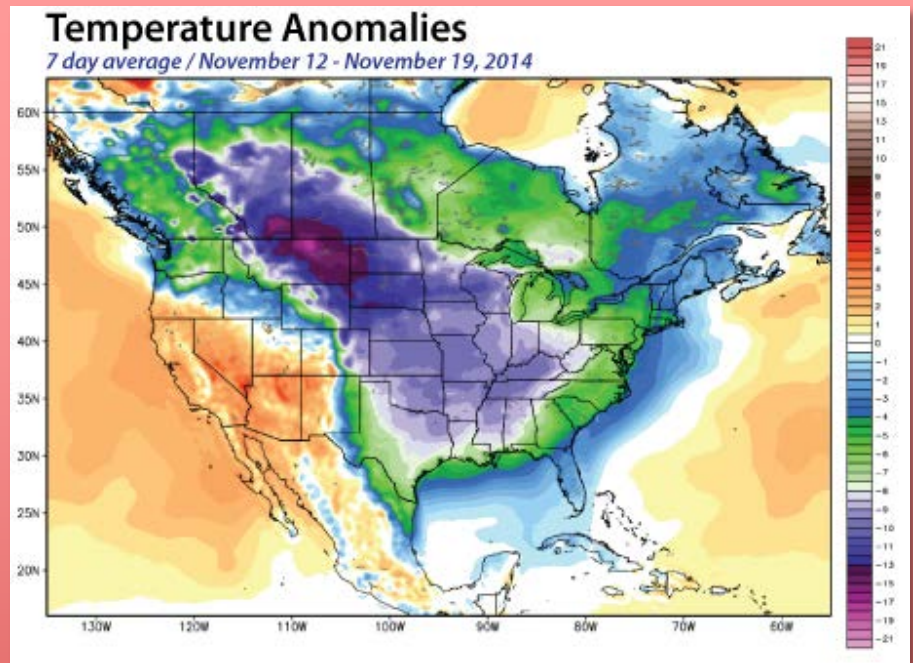
The nation's Energy Minister, Mandi Hoon, said that the UK does not receive any gas directly from Russia, but if there are supply problems to other nations, gas flows to Europe could be affected, which could in turn affect supplies to the UK. Officials expect that the winter will be a "tough one" for the UK.

**■** Months before authorities are reminding people that they have made adequate contingency plans, it should be noted the plans are based on assumptions that this winter will have the same demand (and similar temperatures) as last year.

based on assumptions that this winter will have the same demand (and similar temperatures) as last year.

 Mount Sheveluch in Russia remains restless. On October 28 and 30 the volcano erupted, with the ash plumes rising 11 km (6.8 miles) high. This is not large enough to affect climate, but it is large enough to enter the next passing cold front and bring a freeze around the second week of November.

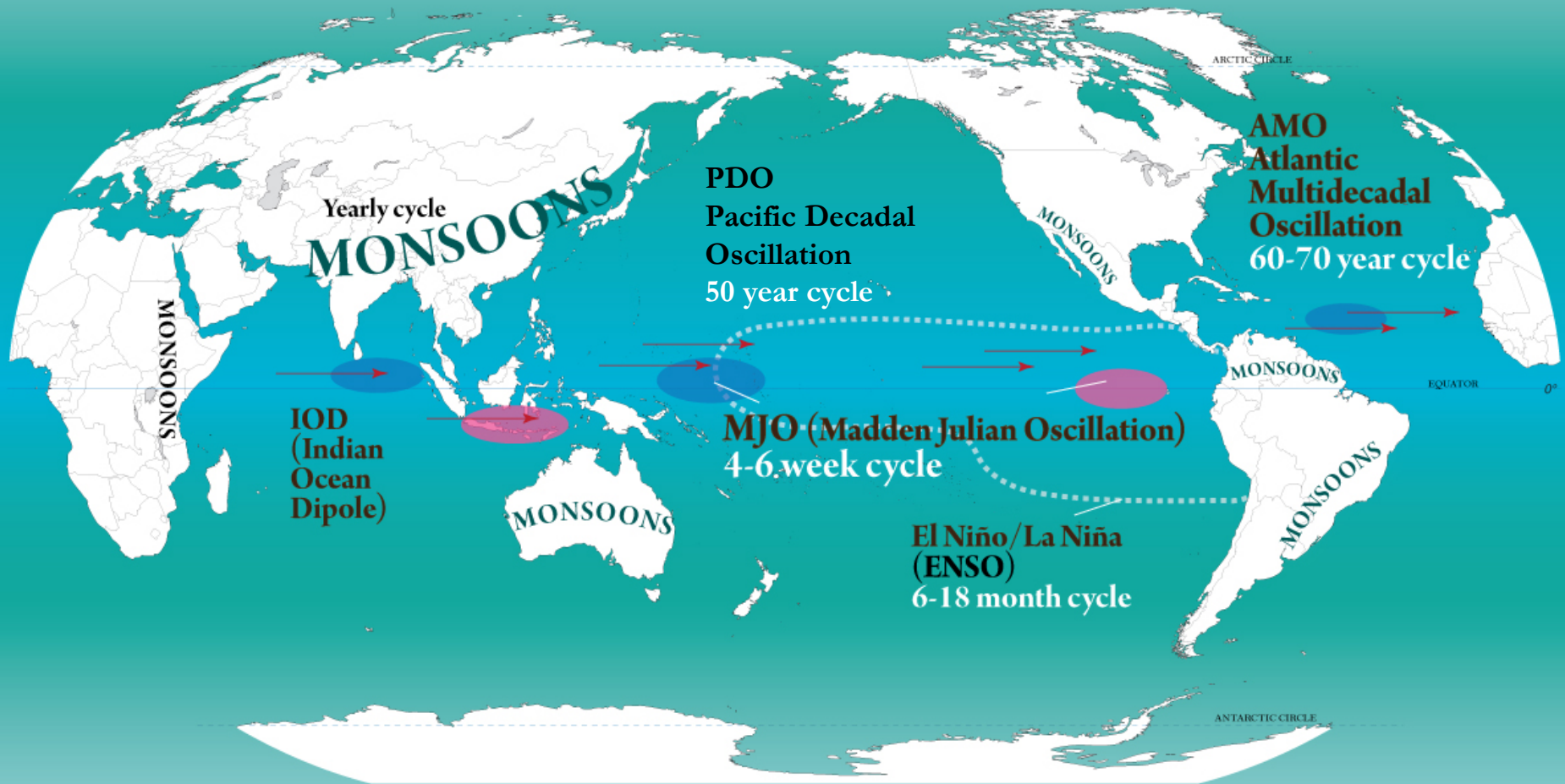
 Did you see the zombie hurricane that attacked Washington and British Columbia? This is the Halloween appropriate nickname some weather watchers are giving the still dangerous remnants of hurricane Ana. The problem is that a hurricane may lose its name, its structure and even its place on



The November newsletter warned that a Russian volcano would trigger a cold spell in the 2<sup>nd</sup> week of November.

courtesy: NOAA/NCEP  
[http://graphical.weather.gov/sectors/conusWeek.php#t](http://graphical.weather.gov/sectors/conusWeek.php#tabs)  
 abs

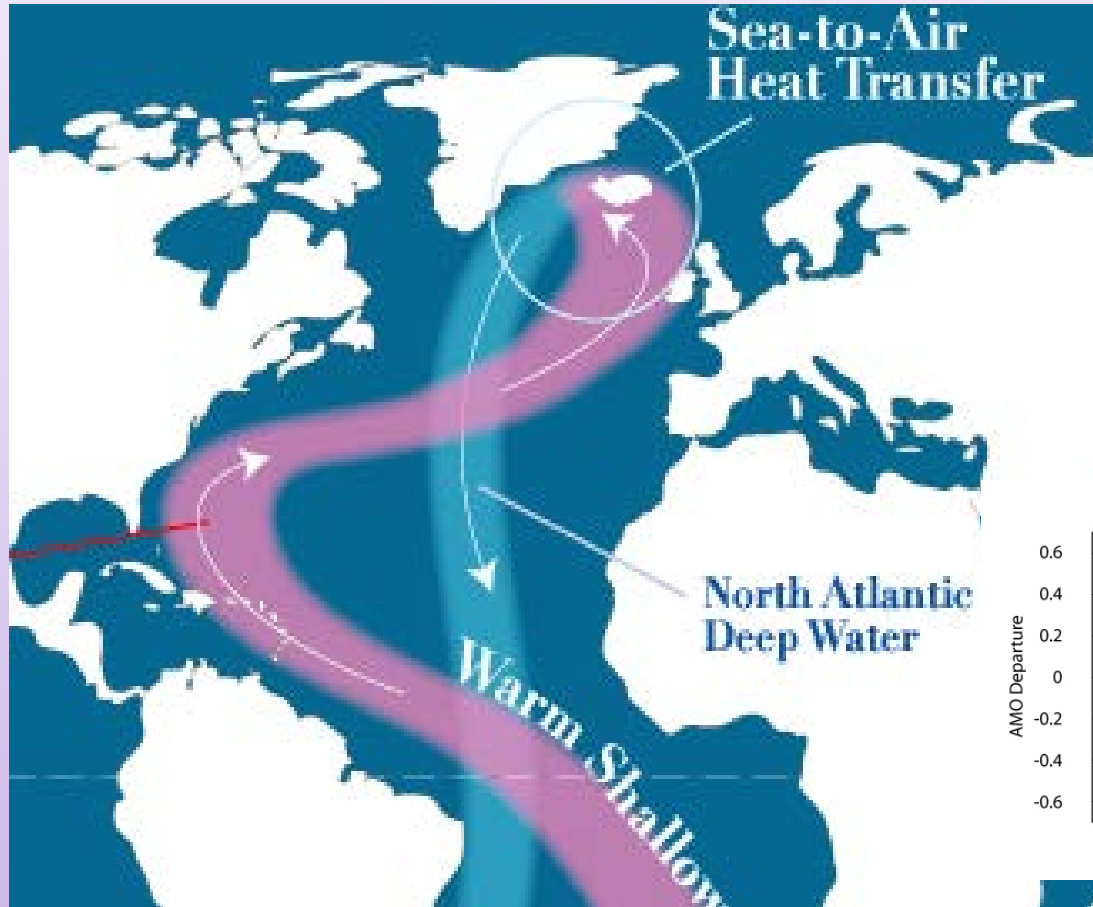
# Oceans store and transport heat



There are several oscillating patterns of ocean currents.



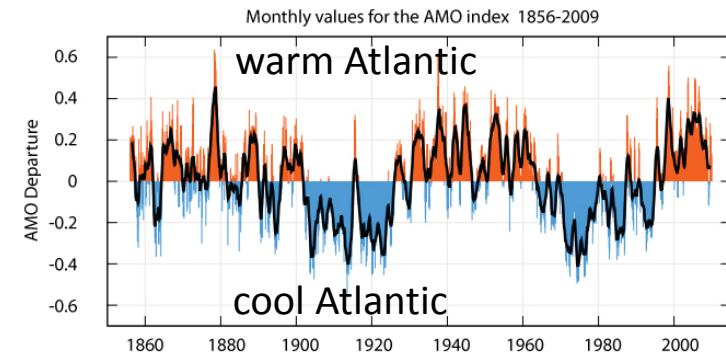
# Oceans store and transport heat



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

The Gulf stream flows faster.

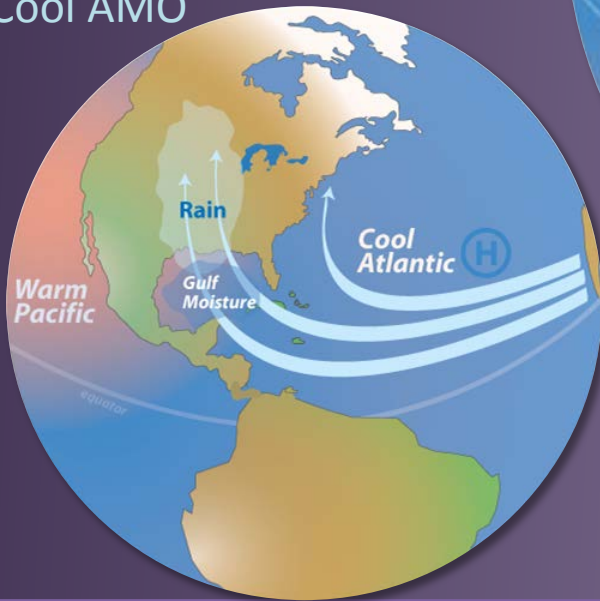
The North Atlantic warms.



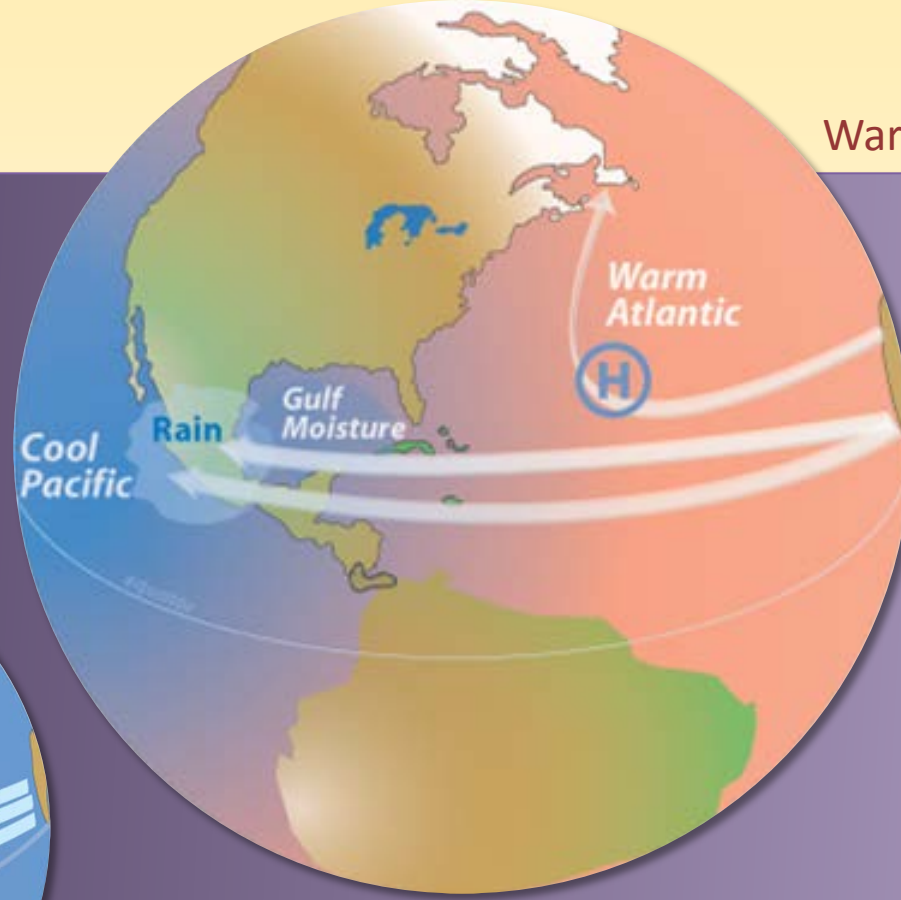
The Atlantic Multidecadal Oscillation (AMO) 1856-2009

[http://en.wikipedia.org/wiki/File:Amo\\_timeseries\\_1856-present.s](http://en.wikipedia.org/wiki/File:Amo_timeseries_1856-present.s)

Cool AMO



Warm AMO



The warm phase of the AMO diverts precipitation from the Prairie Provinces, Gulf, and Great Plains.

**This increases the risk of heat waves, droughts and wildfires.**



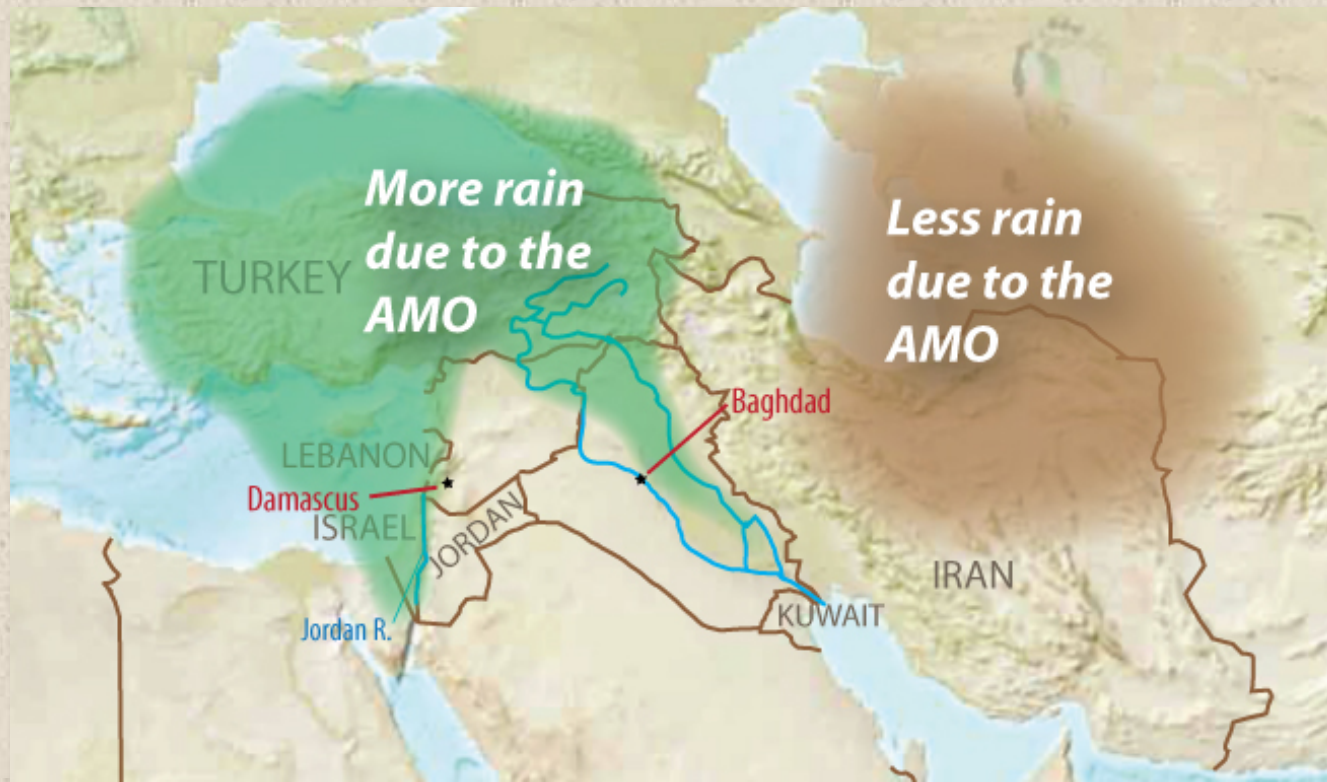


## Negative NAO



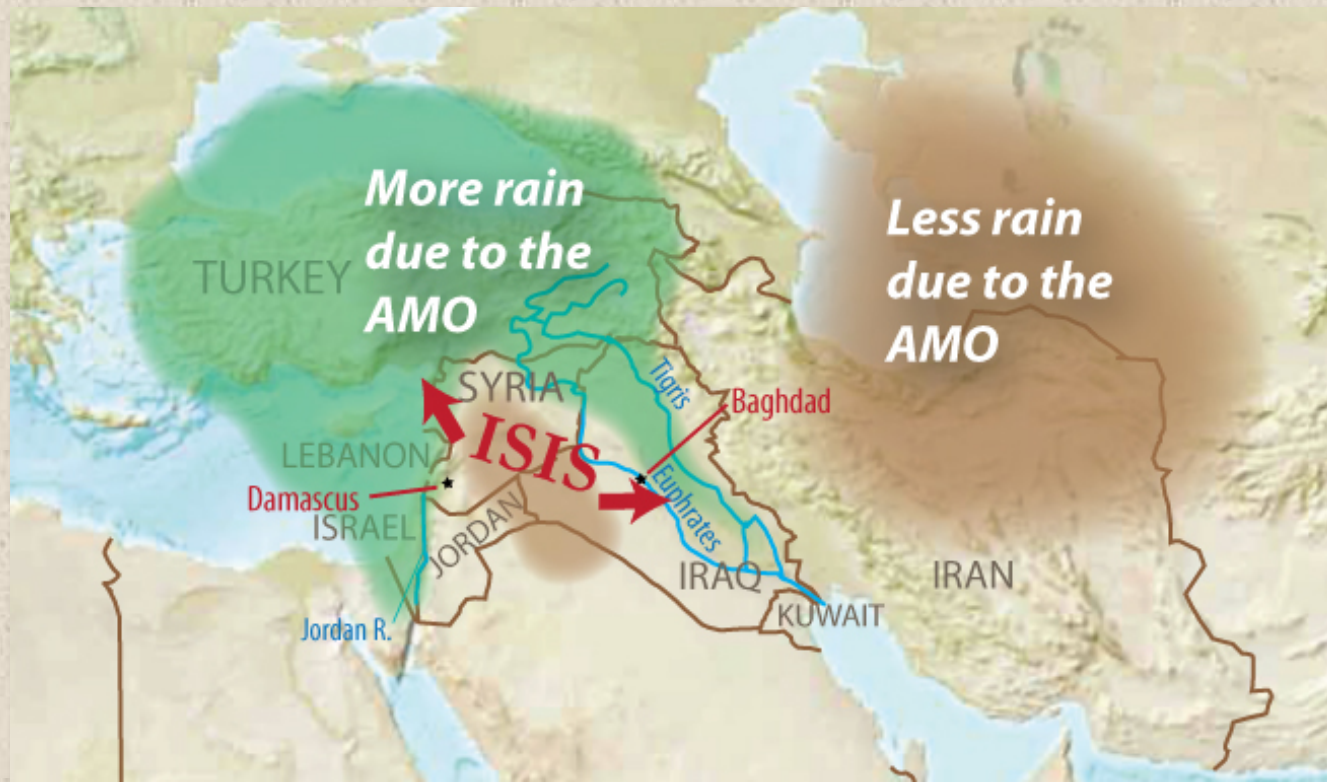
## Positive NAO

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



The Positive AMO redistributes scarce water in the Middle East.

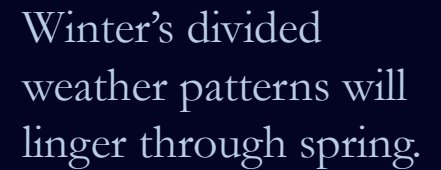




The Positive AMO redistributes scarce water in the Middle East.

Diagram illustrating the weather patterns over North America, showing the Jet Stream flowing from the Pacific Ocean (labeled 'Warm Dry') towards the Atlantic Ocean (labeled 'Stormy' and 'WARM WATER'). The Jet Stream is depicted as a blue arrow. The Pacific side is associated with a High Pressure system (H), and the Atlantic side is associated with a Low Pressure system (L). The text 'BITTER ARCTIC COLD' is also visible over the northern part of the continent.

Last winter, North America was dominated by a hugely variable jet stream that brought extreme weather to both sides of the continent.



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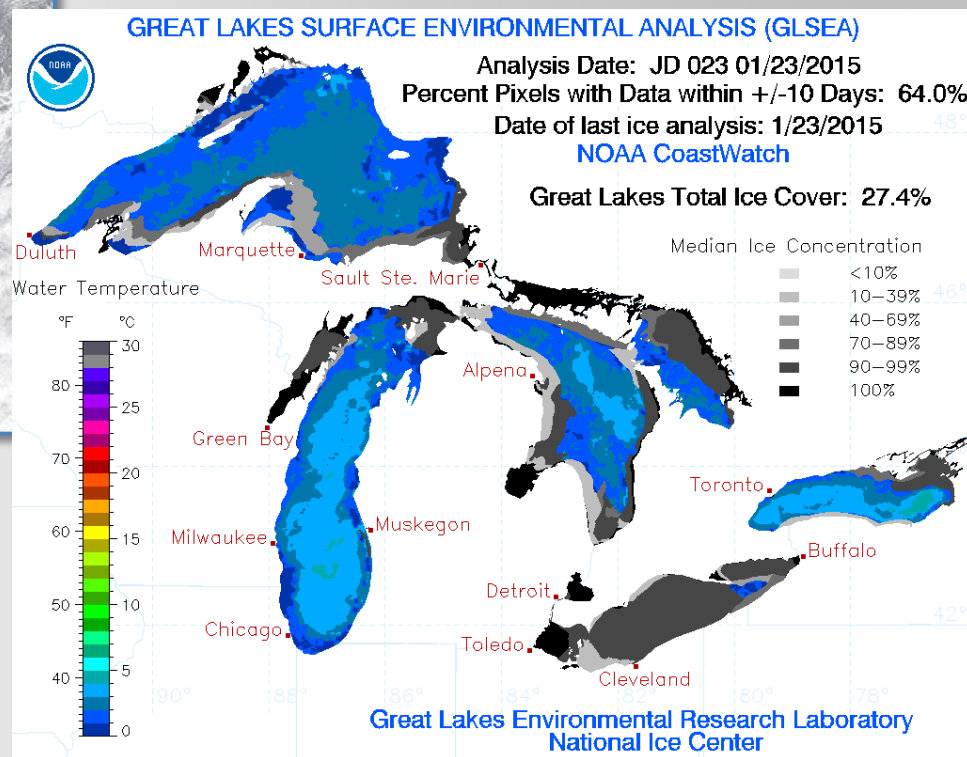


# 2014



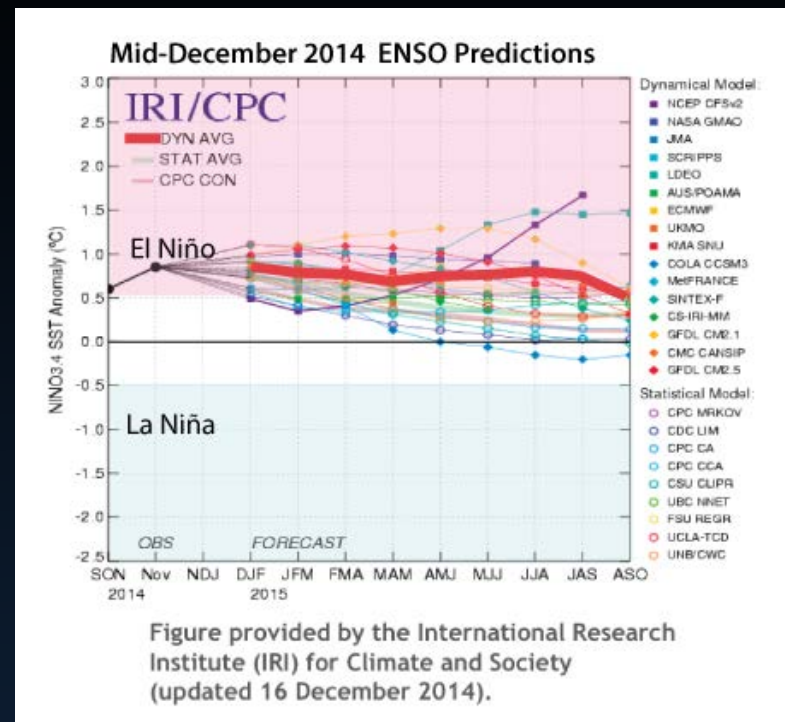
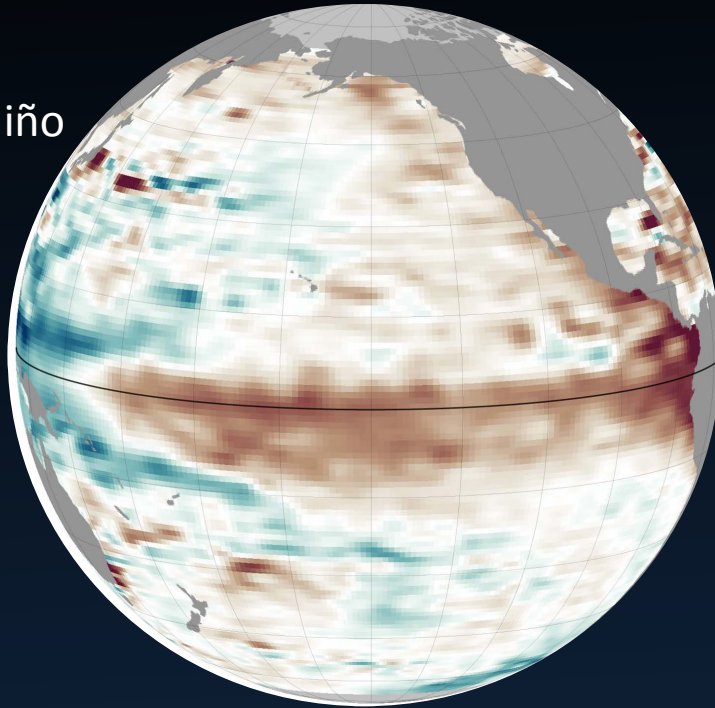
Last winter 92% of the Great Lakes were covered with ice and the ice lingered until June, cooling spring.

# 2015



So far, this year is matching last year, but experts expect only average cover.

El Niño

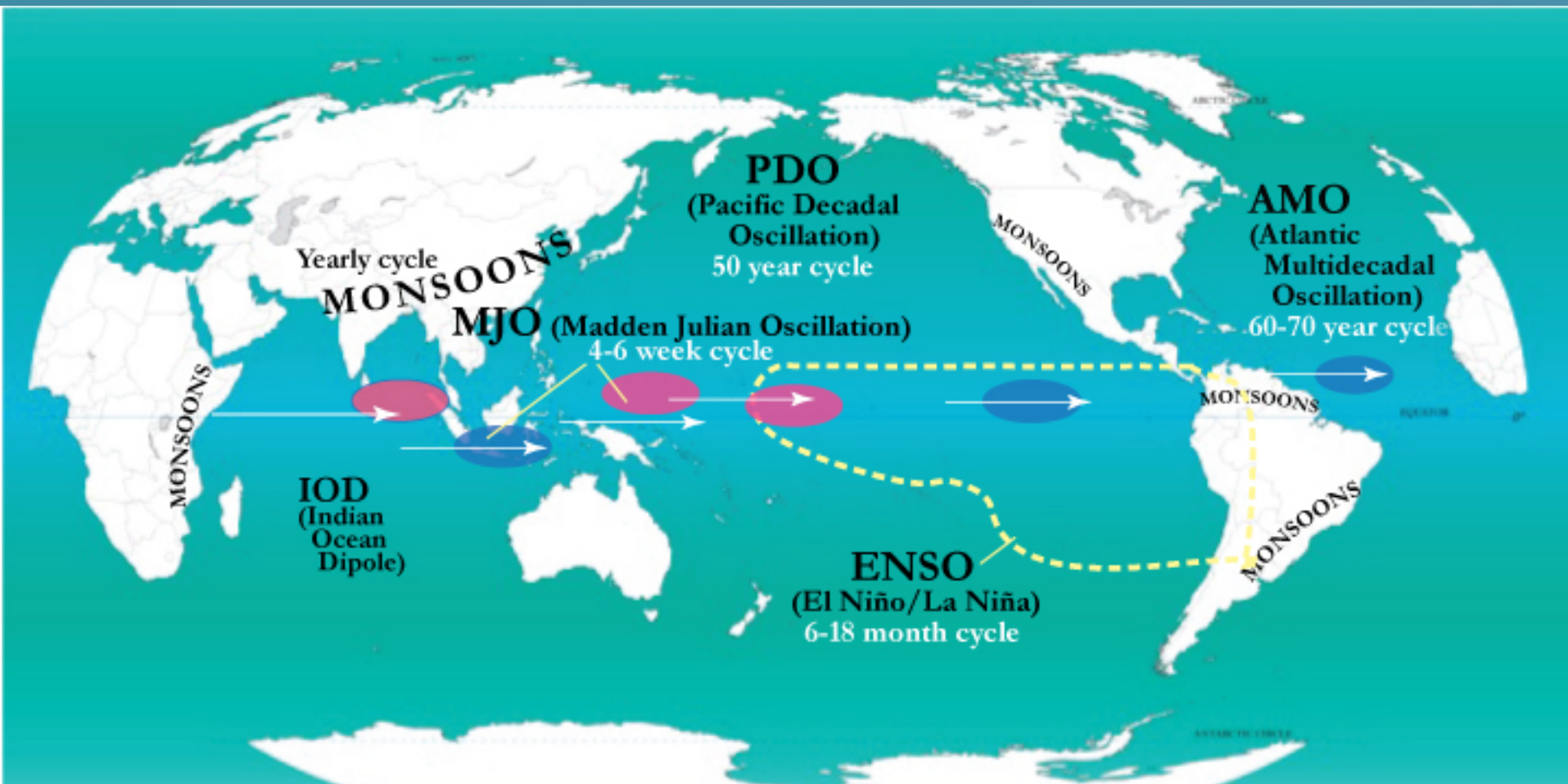


El Niño conditions developed in the Central and Eastern Tropical Pacific in Late May.

These conditions faded but **experts say there is a 60%+ chance of an El Niño event returning.**

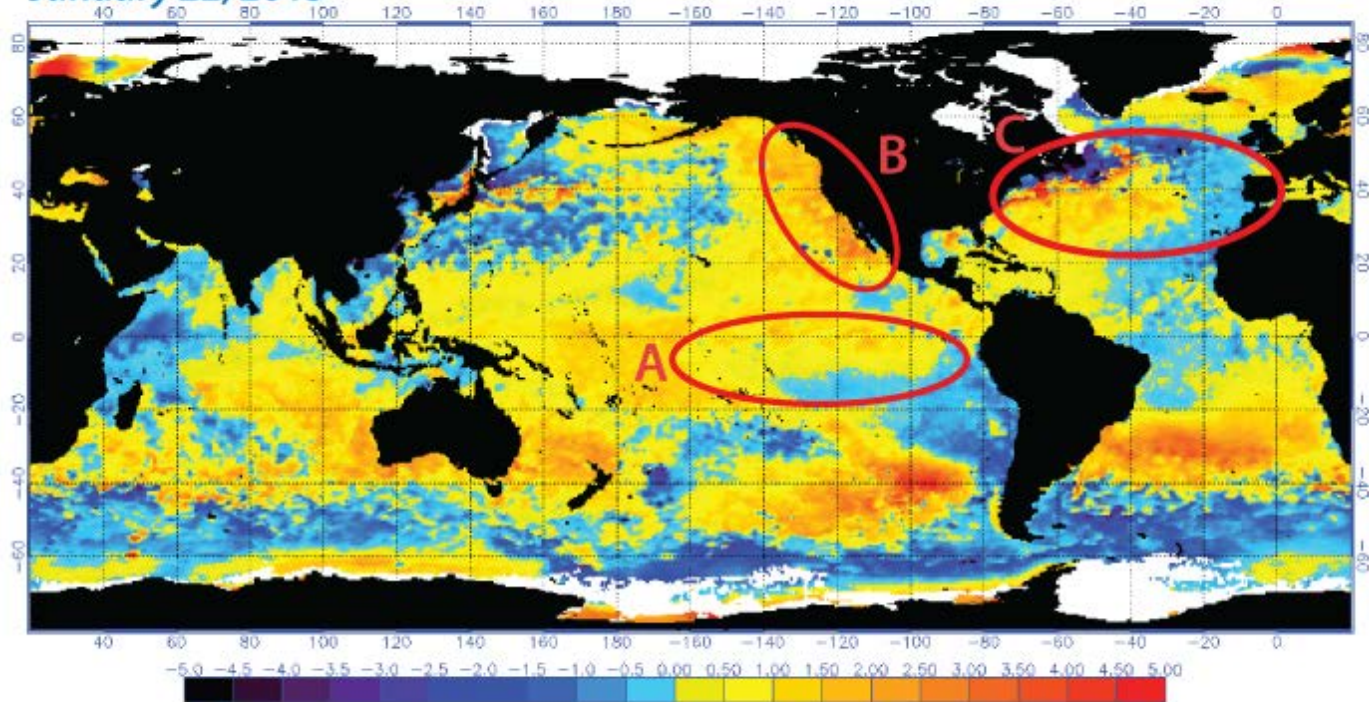


## Remember the hot and cool MJOs



A cool MJO churned up the El Niño conditions starting in July  
and two warm MJOs are reheating it.

## Global Sea Surface Temperature Anomalies (°C) *January 22, 2015*

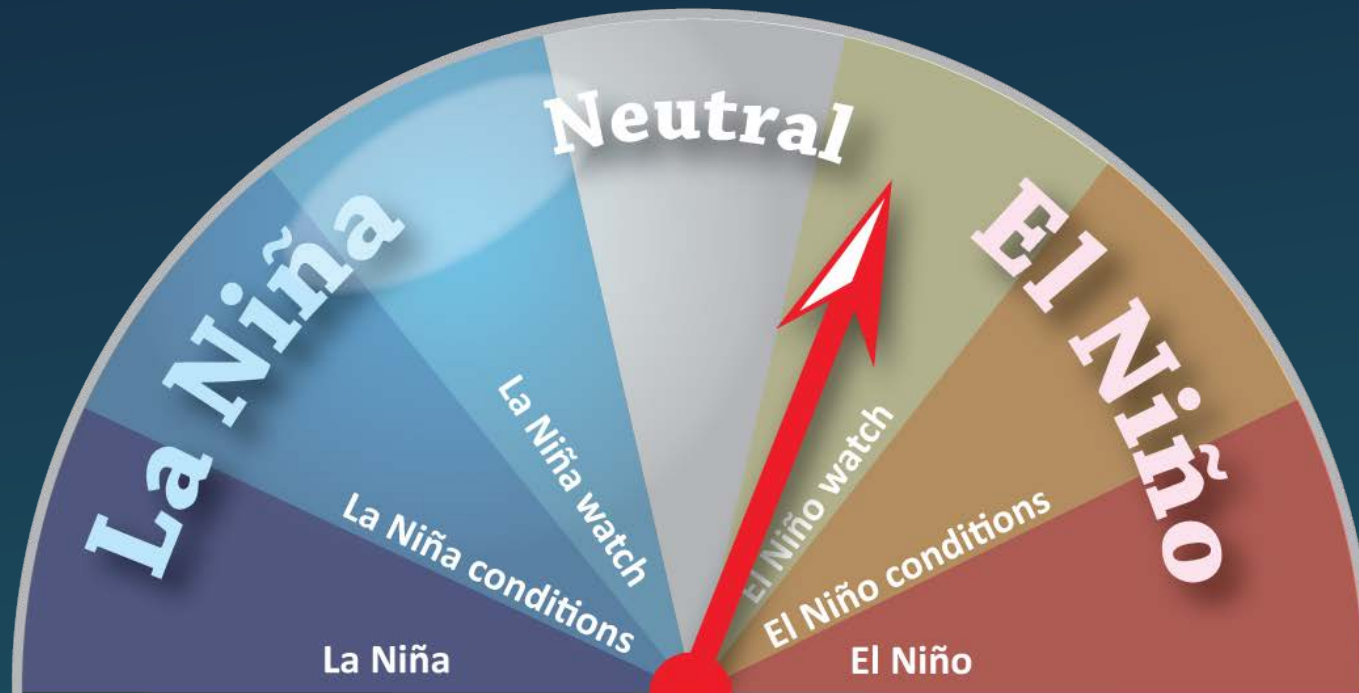


- A** El Niño conditions
- B** Warm temperatures along the West Coast of North America
- C** The Western North Atlantic remains warm but the Eastern side is cooling.

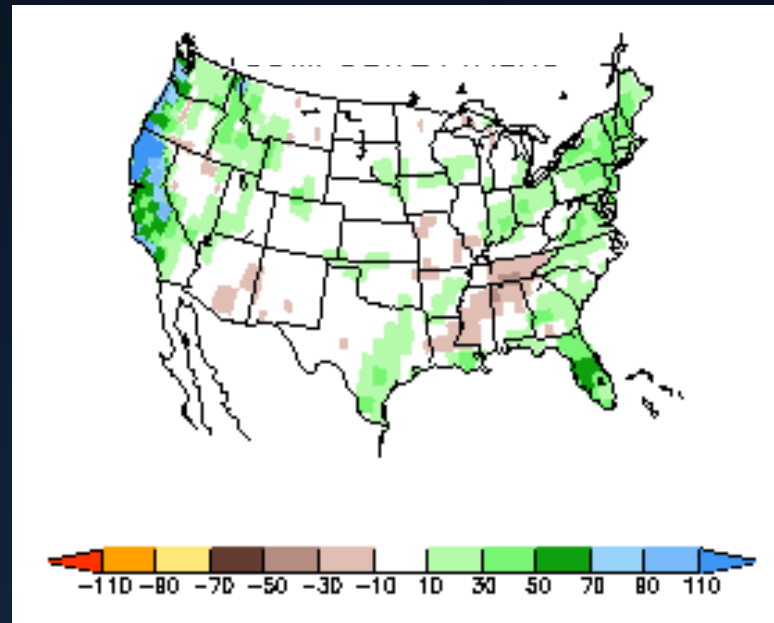
<http://www.ospo.noaa.gov/data/sst/anomaly/2015/anomnight.1.22.2015.gif>



Even though there is only an official El Niño watch, it is creating El Niño weather patterns.



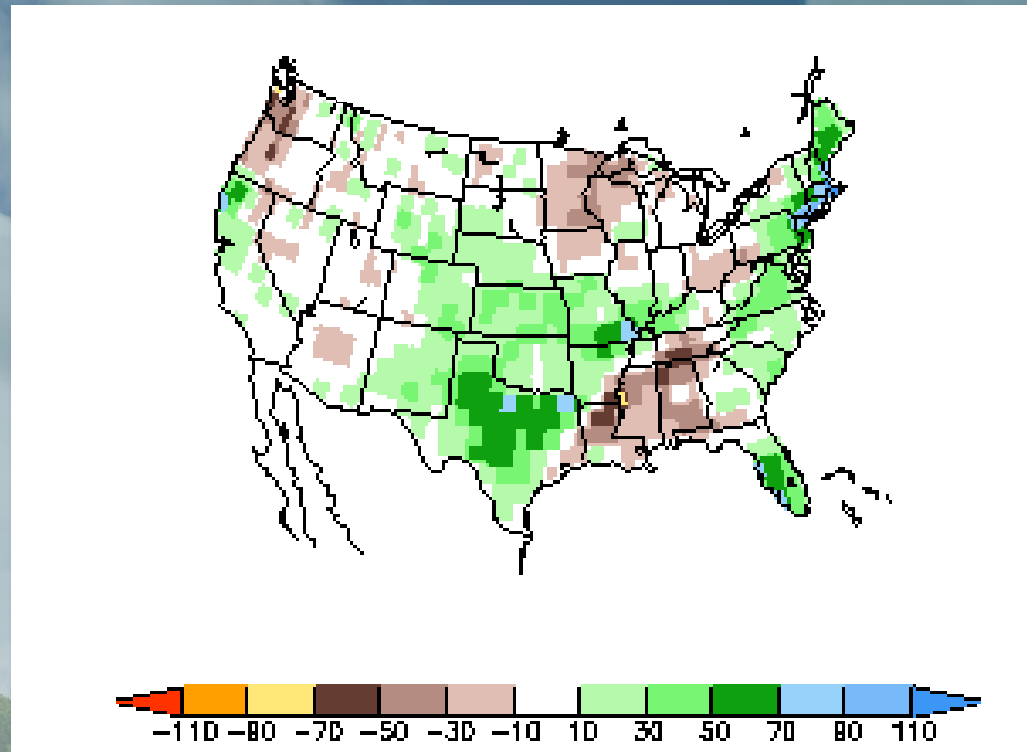
Winter and Spring will be shaped  
by how big and long lasting the El Niño is.



December/ January/February  
Precipitation Anomalies during El Niño



## Precipitation Anomalies



March/April/May

If the El Niño conditions become an El Niño,  
this is the most likely conditions in spring:

mid-January to mid-February



mid-February to mid-March



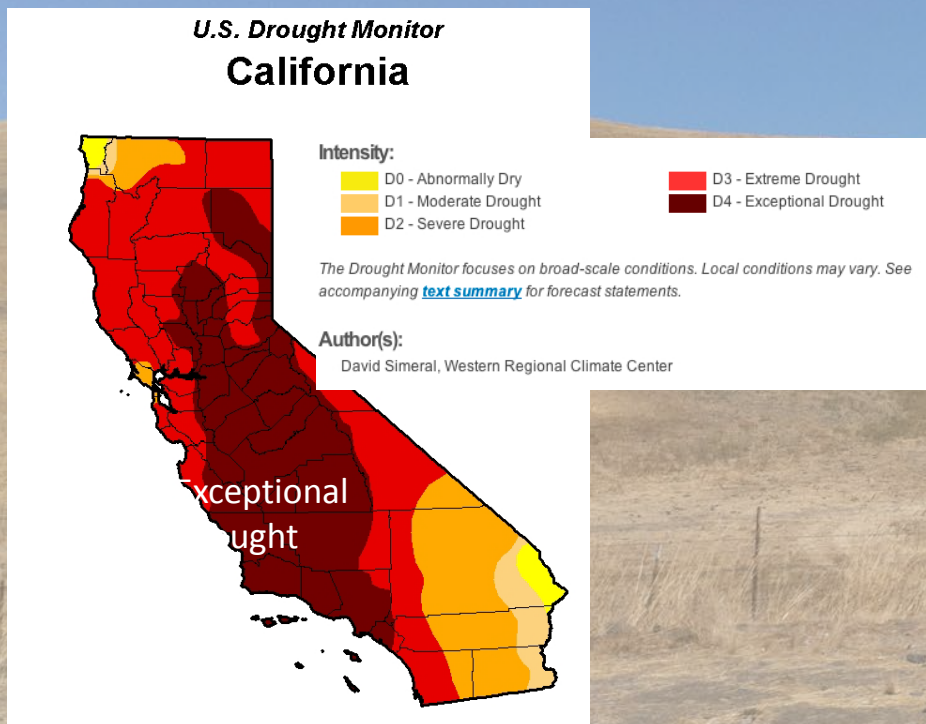
\* If El Niño conditions continue

✦ A moderate Russian volcanic eruption will make this region colder.

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

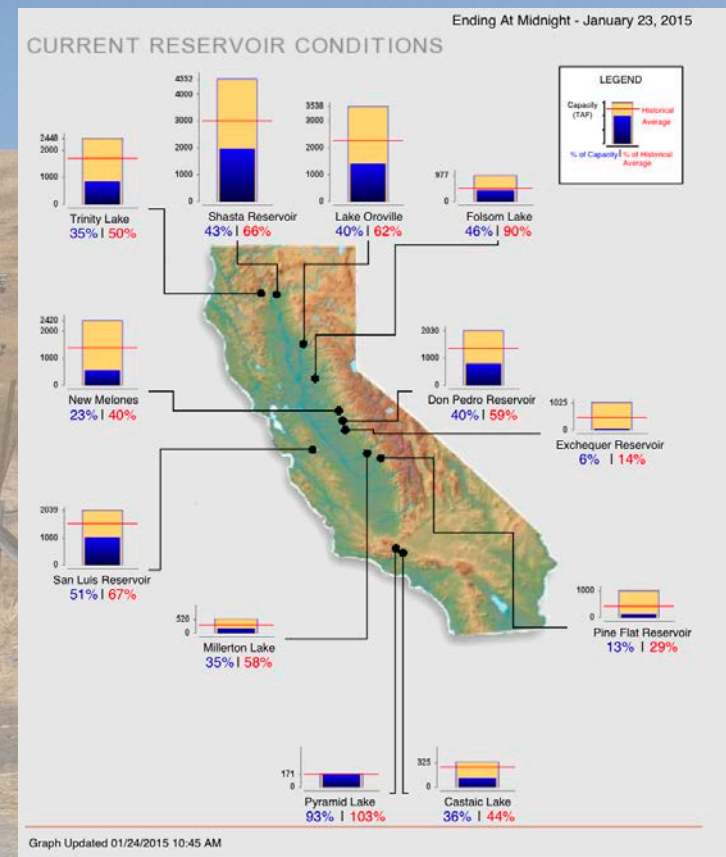


The California drought is affecting 37.2 million people.  
**100% of the state is in drought** and 39% is in the most severe state of drought. Currently the state reservoirs stand at 61% of average.

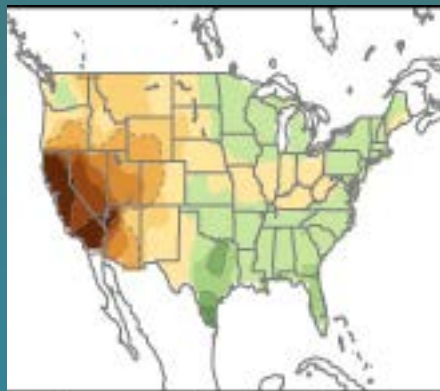
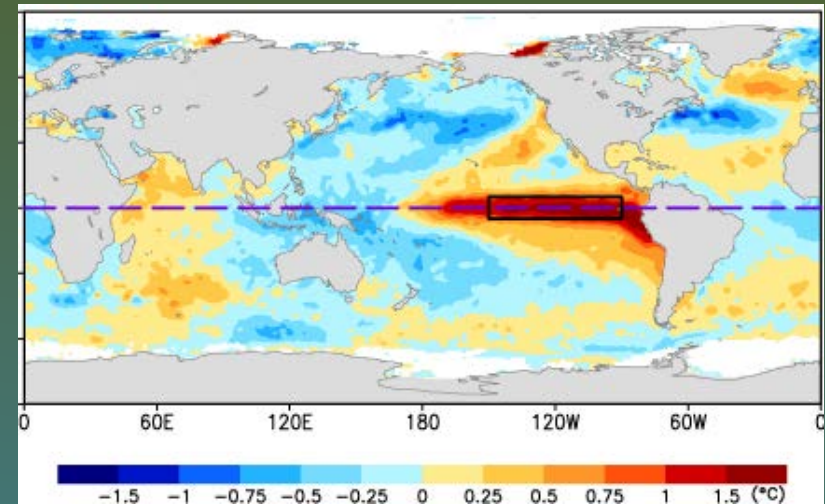
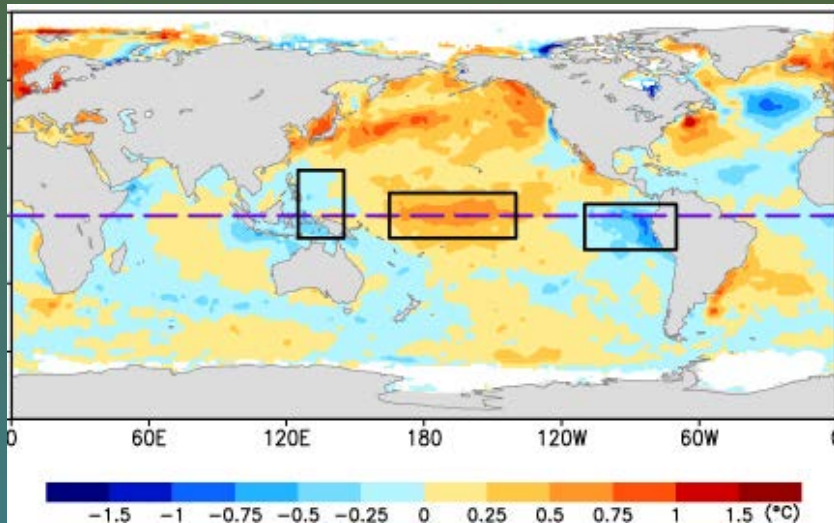


<http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?CA>

Even heavy rainfall will not end California's long-term drought.



<http://cdec.water.ca.gov/cgi-progs/products/rescond.pdf>

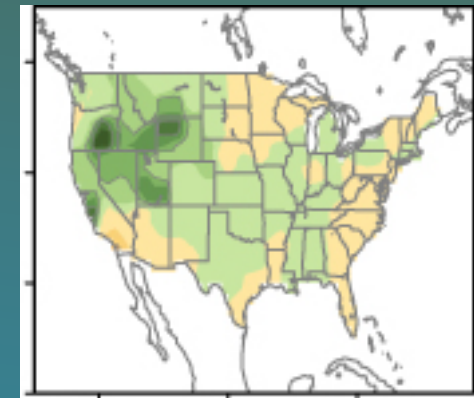


**El Niño Modoki**

One thing to look out for

– the Japanese are warning that they see a strong possibility of the El Niño conditions shrinking to a Central Pacific El Niño, an **El Niño Modoki**.

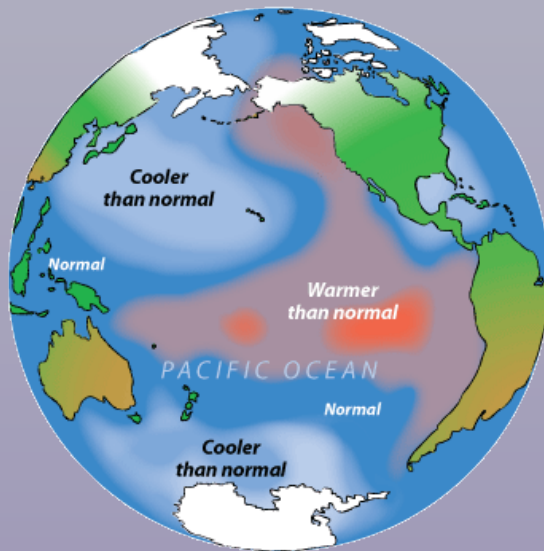
If that happened, it would cut off most of the springtime rain to California.



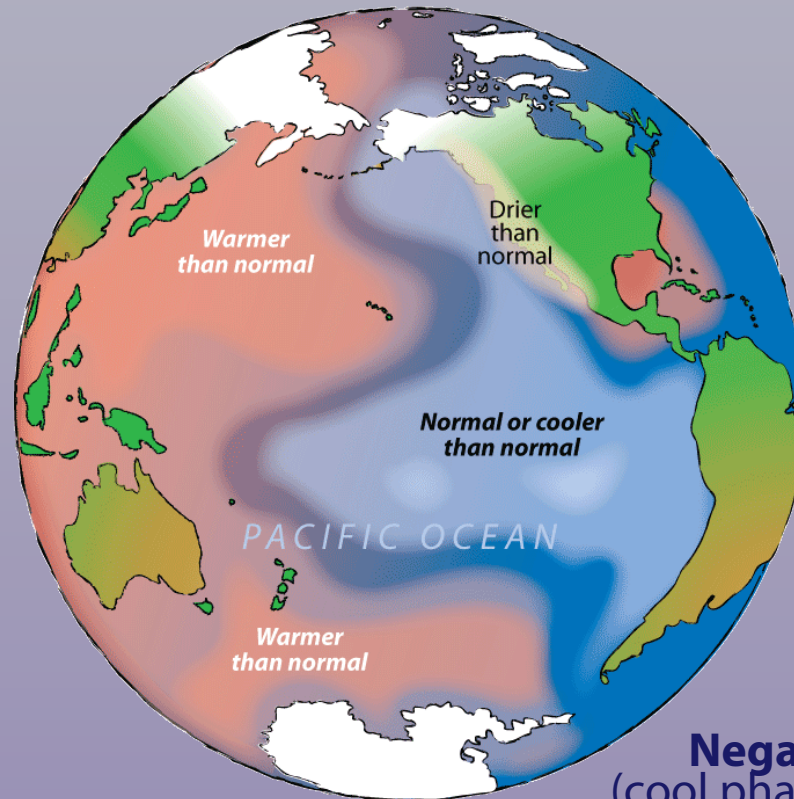
**El Niño**



There is a new paradigm in the Pacific –  
The **Pacific Decadal Oscillation** tipped from a positive  
to a negative trend in 2006.



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



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

**The Pacific Decadal Oscillation**  
Each phase lasts 20-30 years

# The PDO's impact on precipitation

## Winners

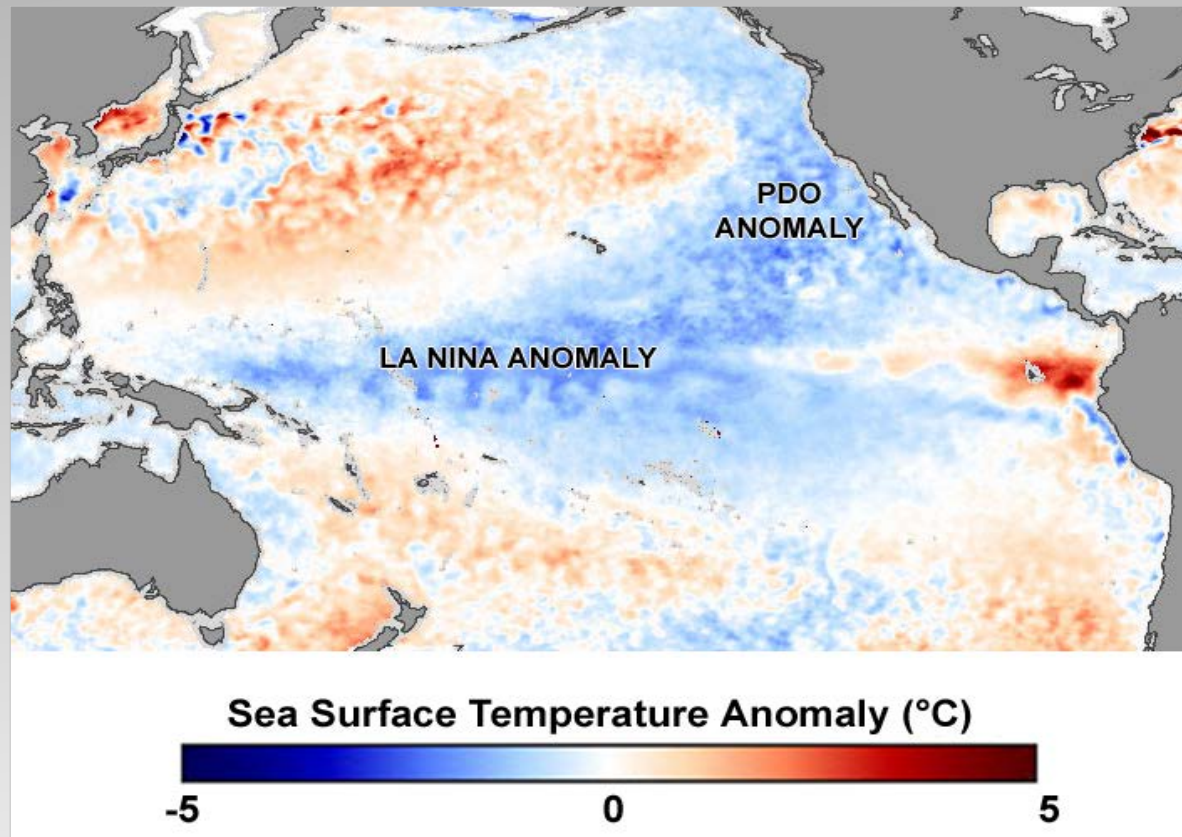
- Midwest US
- *STRONGER MONSOON*:  
Northern & Central China
- *STRONGER MONSOON*: India
- *STRONGER MONSOON*: Japan
- Brazil
- Southern Africa
- *STRONGER MONSOON*:  
Eastern Australia

## Losers

- California/Southwest US
- *WEAKER MONSOON*:  
Southern China
- *WEAKER MONSOON*: Pakistan
- *WEAKER MONSOON*: North Korea
- Andes Republics/  
Southern Argentina
- East Africa
- *WEAKER MONSOON*:  
Western Australia

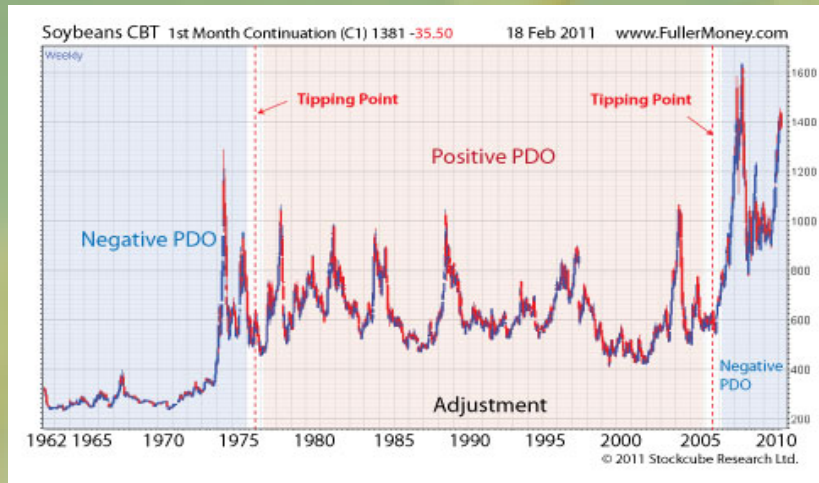


**A La Niña magnifies the impact of a cold PDO.**

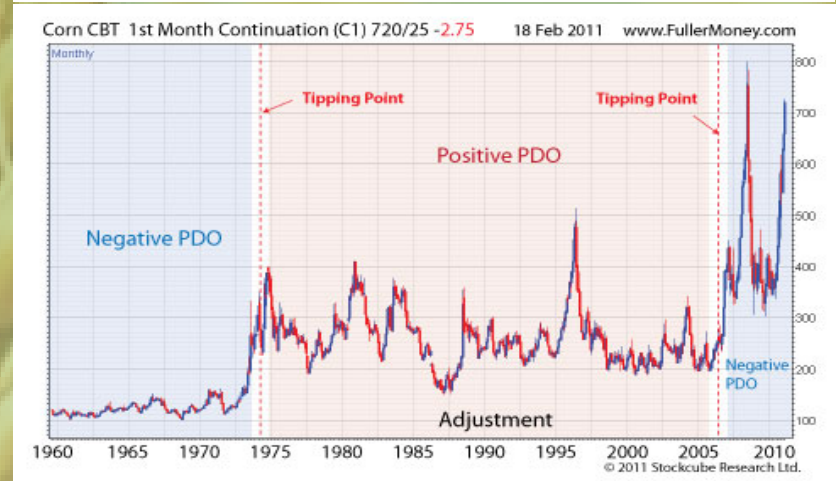


# The impact on agriculture

## Soybeans 1962-2011

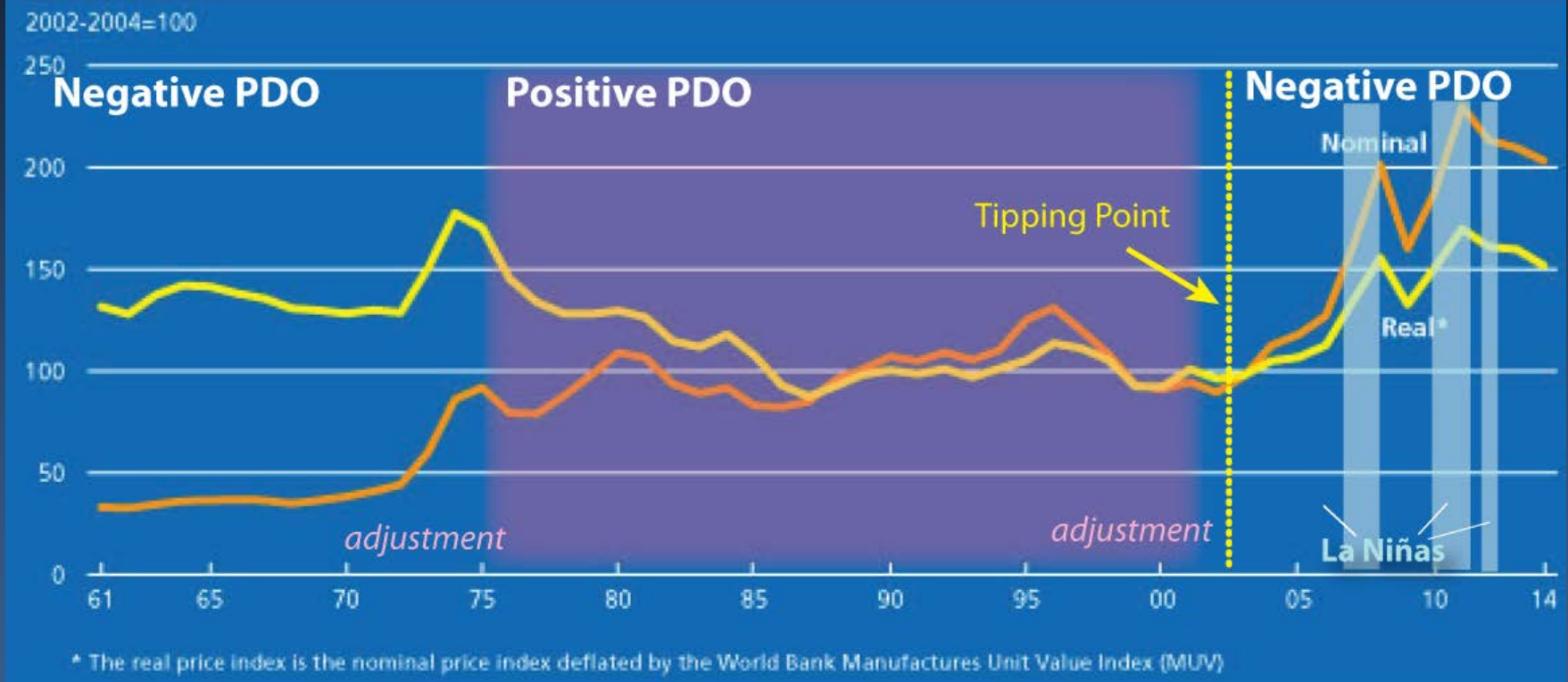


## Wheat 1960-2011



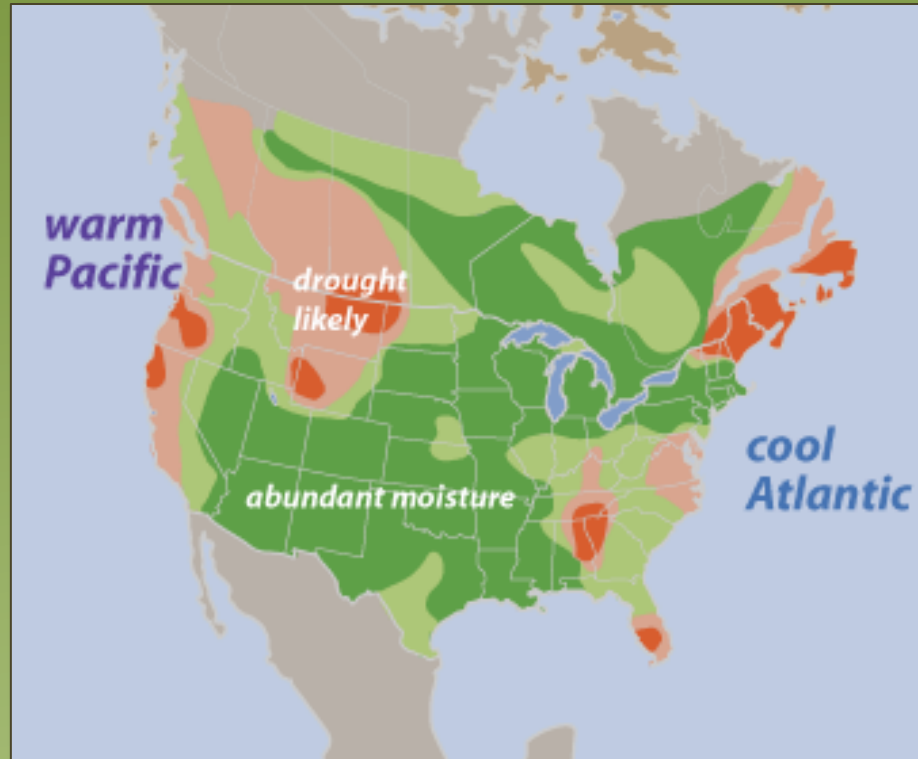
## Corn 1960-2011

## FAO Food Price Index: 1961-2014



courtesy: FAO

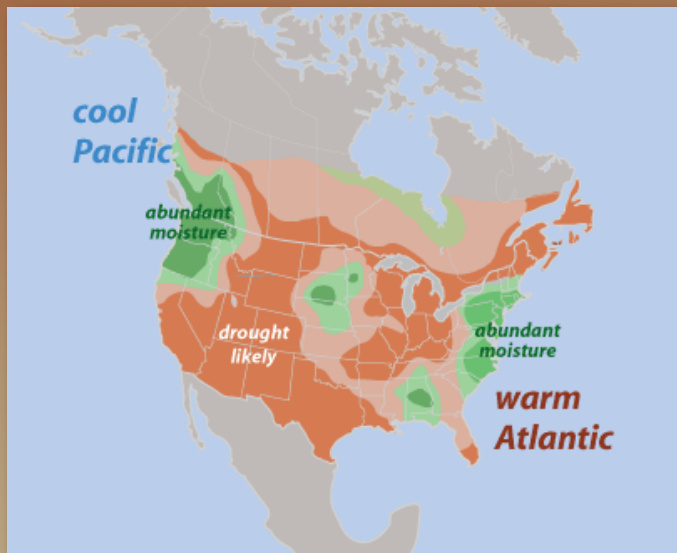




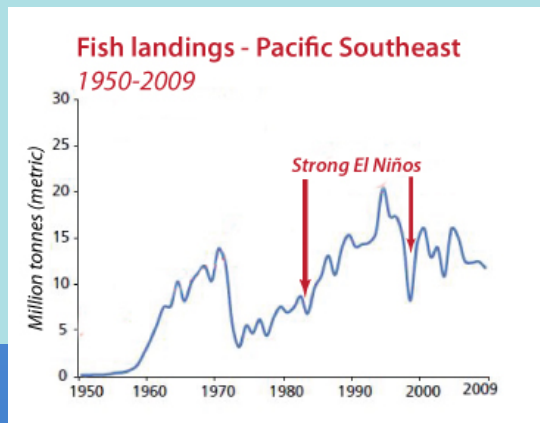
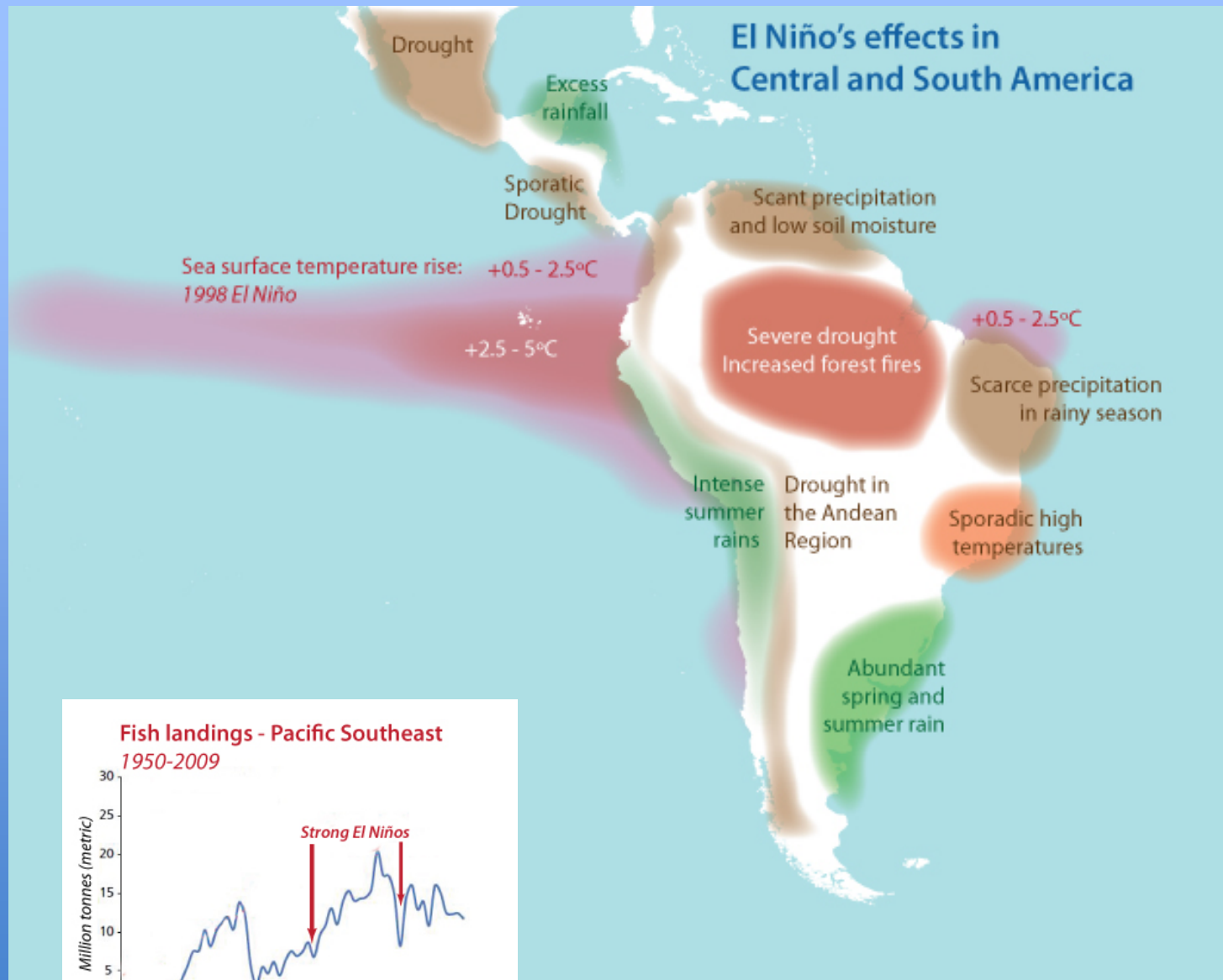
## The Atlantic AMO changed in 1995.

The Pacific Decadal Oscillation is less stable but from the mid 1970s to the late 1990s the US & Canada enjoyed the most benign combination of the PDO and AMO.

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



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.



## El Niño and South America





Outlook for  
**SOUTH  
AMERICA**  
over the next  
10 years.

# Conclusions

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THE

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