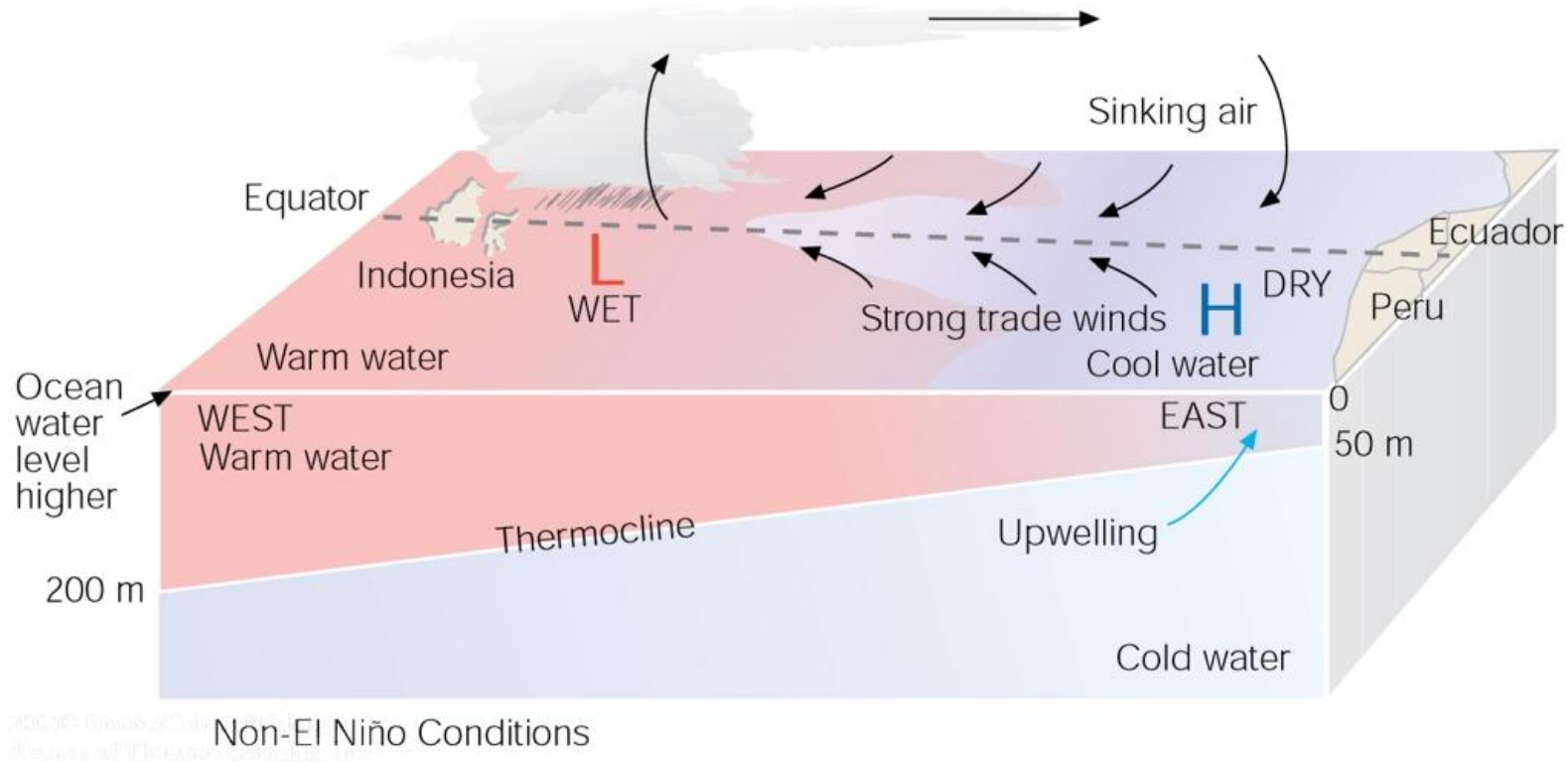


Lecture 9: Natural interannual to decadal climate variability

[EarthsClimate_Web_Chapter.pdf](#), p. 22-27; Ch. 16, p. 299-302; Ch. 17, p. 321-324

- Main atmosphere-ocean interaction phenomena:
 - El Nino-Southern Oscillation (ENSO)
 - North Atlantic Oscillation (NAO)

Air–Sea Interactions in the Pacific: Normal Conditions



Atmosphere: Subtropical **H** near coasts of Peru and Ecuador. **L** in the west.

Sinking air in the east: dry. Rising air in the west: wet.

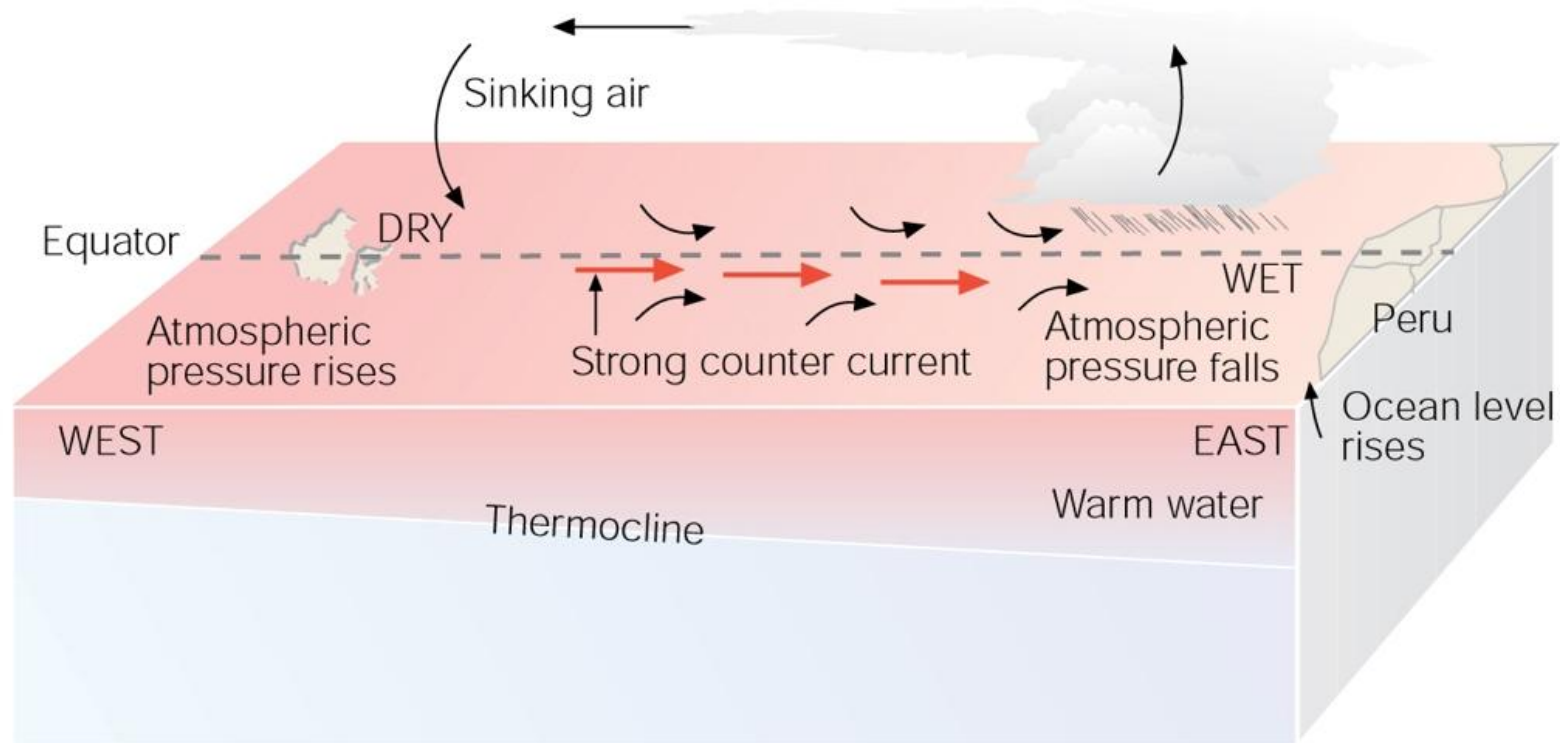
Strong easterly trade winds, part of Walker Circulation.

Ocean: **Cool** surface water in the east because of upwelling

Warm surface water in the west because of trade winds

Fisheries in the east: **Excellent**

Air–Sea Interactions: El Niño Conditions



El Niño Conditions

- Atmosphere:** **Pressure in the east falls.** **Pressure in the west rises.**
Rising air in the east: wet. **Sinking air in the west: dry.**
Easterly trade winds weaken or reverse.
- Ocean:** **Surface water warms in the east because upwelling stops**
Warm surface water in the west spreads EASTWARD.
- Fisheries in the east:** **Poor**

El Niño-Southern Oscillation (ENSO)

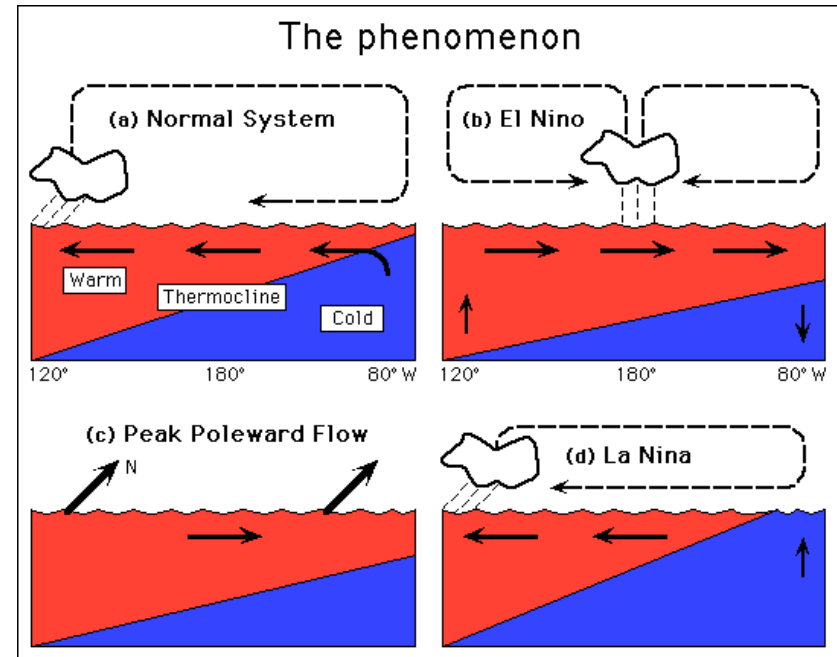
El Niño: Warming of sea surface temperature in the central and eastern tropical Pacific Ocean

Southern Oscillation: A seasaw pattern of reversing surface air pressure at opposite ends of the tropical Pacific Ocean

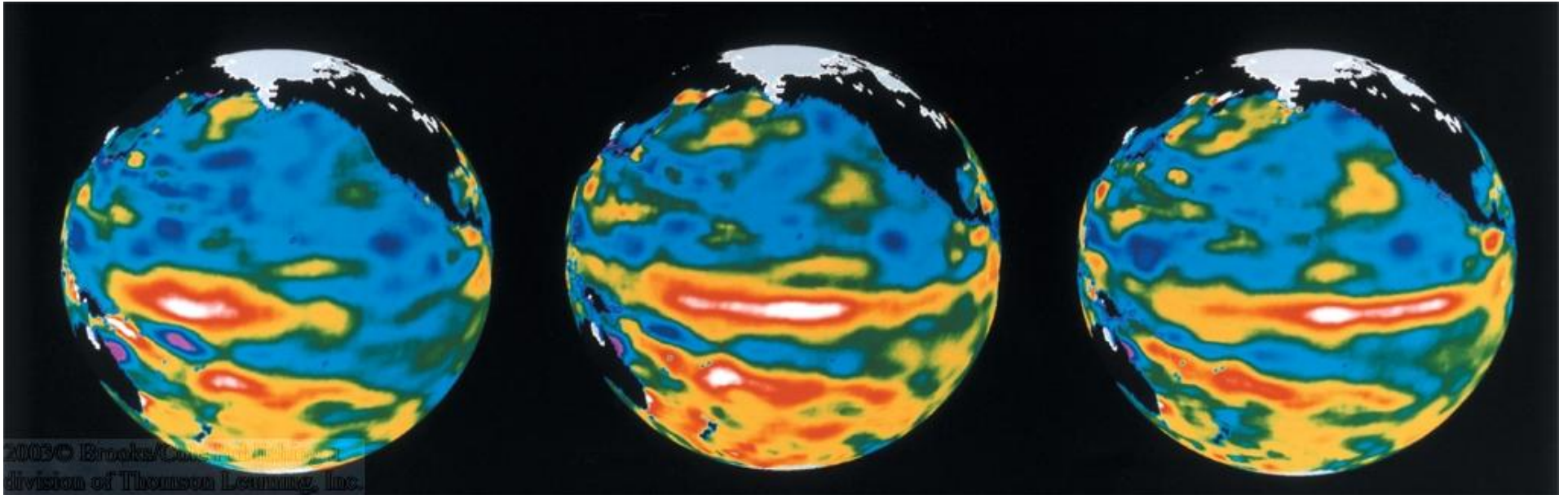
La Niña: Sea surface temperature in the central and eastern tropical Pacific Ocean colder than normal

El Niño and Southern Oscillation are LINKED, thus ENSO.

El Niño events occur about every 2-7 years



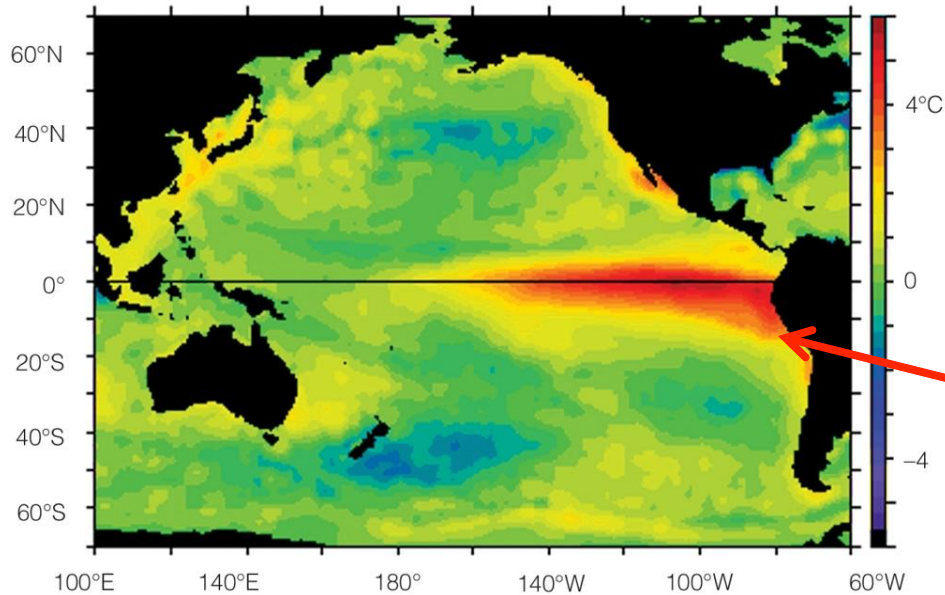
El Nino Seen From Satellite



Satellite imagery shows the eastward movement of higher ocean levels, or **Kelvin wave**, in white and red colors, caused by the reversal of the Walker Circulation and El Nino event.

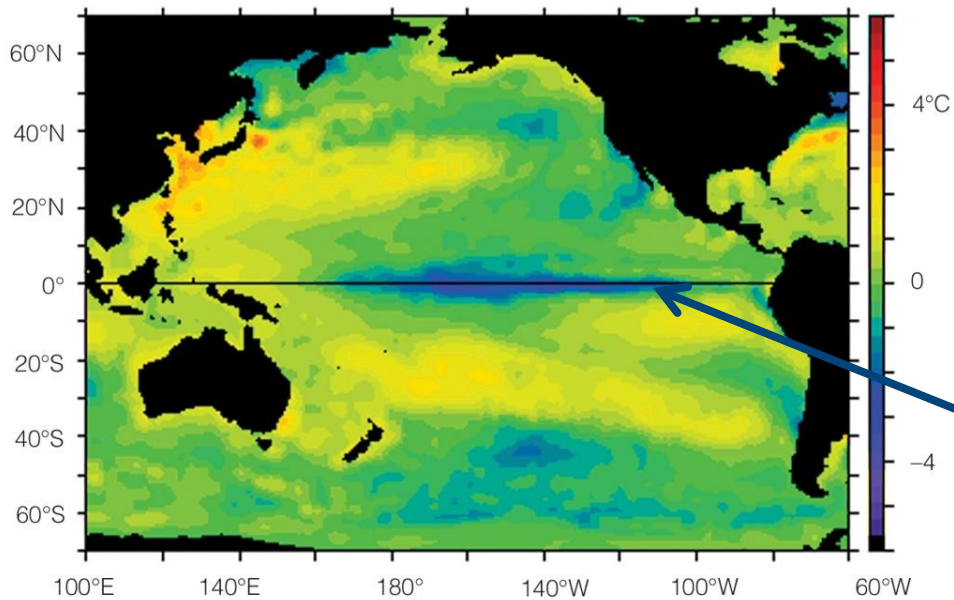
Sea Surface Temperature Departures from Normal as Measured by Satellite

Warmer SST During the El Niño conditions



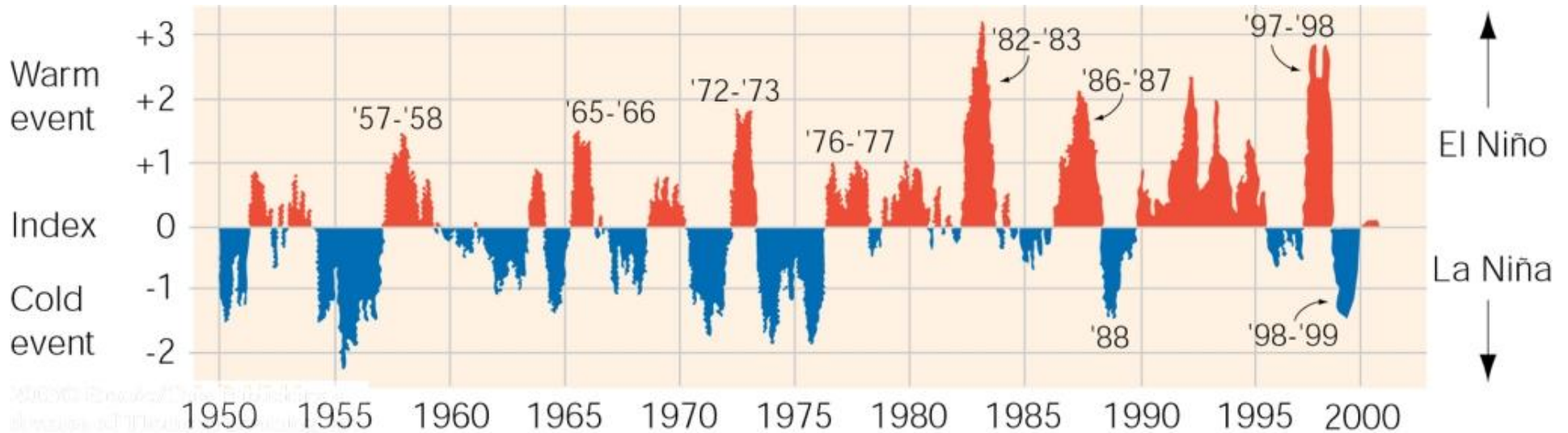
El Niño Conditions, December, 1997

Cooler SST during the La Niña conditions



La Niña Conditions, December, 1998

ENSO Index



El Nino Southern Oscillation (ENSO) intensity has been tracked using 6 parameters, including air and sea temperature, sea level pressure, wind speed and direction, and cloudiness.

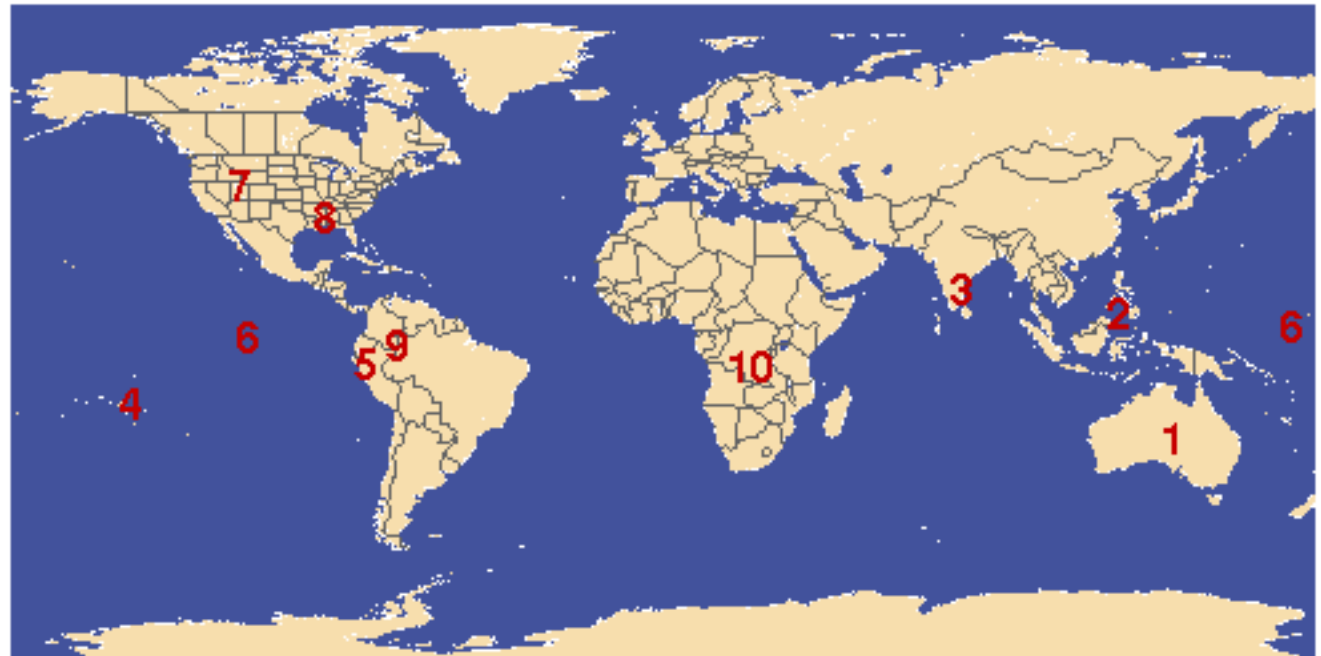
A graph of the ENSO index shows eastern Pacific **warm El Nino and **cool La Nina** years.**

Two largest ENSO events: 1982-83 and 1997-98.

1982/83 El Niño

ENSO is a phenomenon in the tropical Pacific Ocean.

Why should we care about it in Texas?



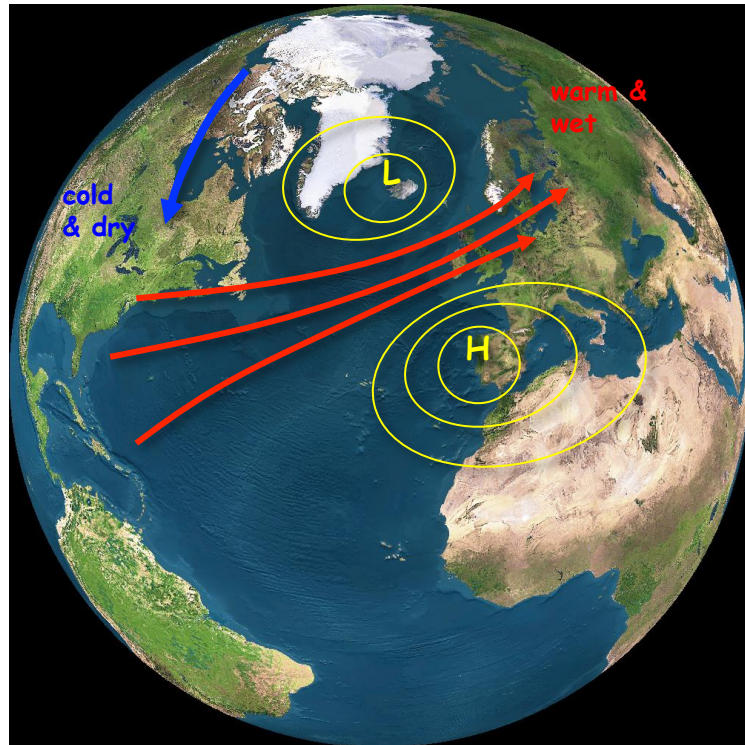
ENSO can impact the weather beyond the tropical Pacific ocean through **teleconnections!**

1. Australia - Drought and bush fires
2. Indonesia, Philippines - Crops fail, starvation follows
3. India, Sri Lanka - Drought, fresh water shortages
4. Tahiti - 6 tropical cyclones
5. South America - Fish industry devastated
6. Across the Pacific - Coral Reefs die
7. Colorado River basin - Flooding, mud slides
8. Gulf states - Downpours cause death, property damage
9. Peru, Ecuador - Floods, landslides
10. Southern Africa - Drought, disease, malnutrition

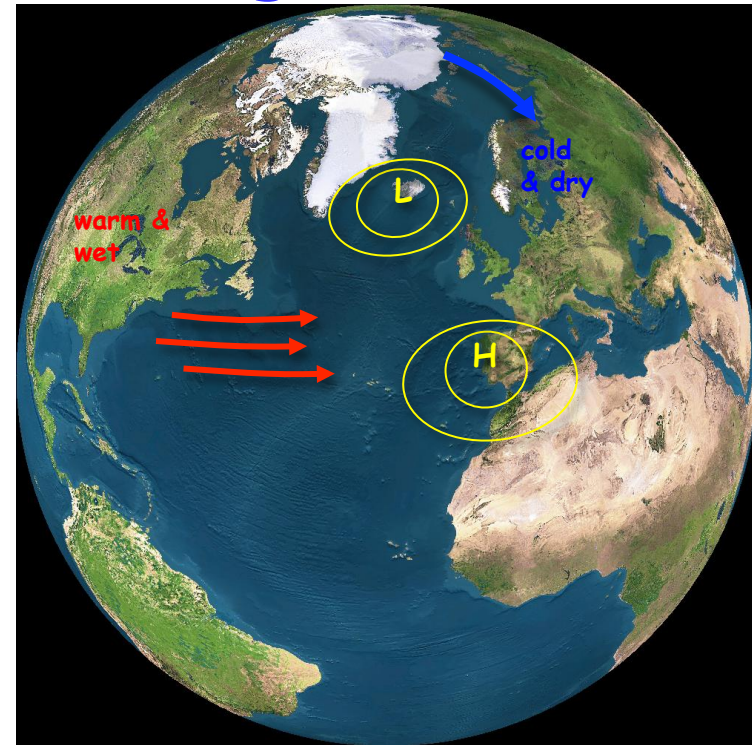
The North Atlantic Oscillation

A fluctuation in atmospheric pressure between Iceland low and Azores high

Positive Phase



Negative Phase

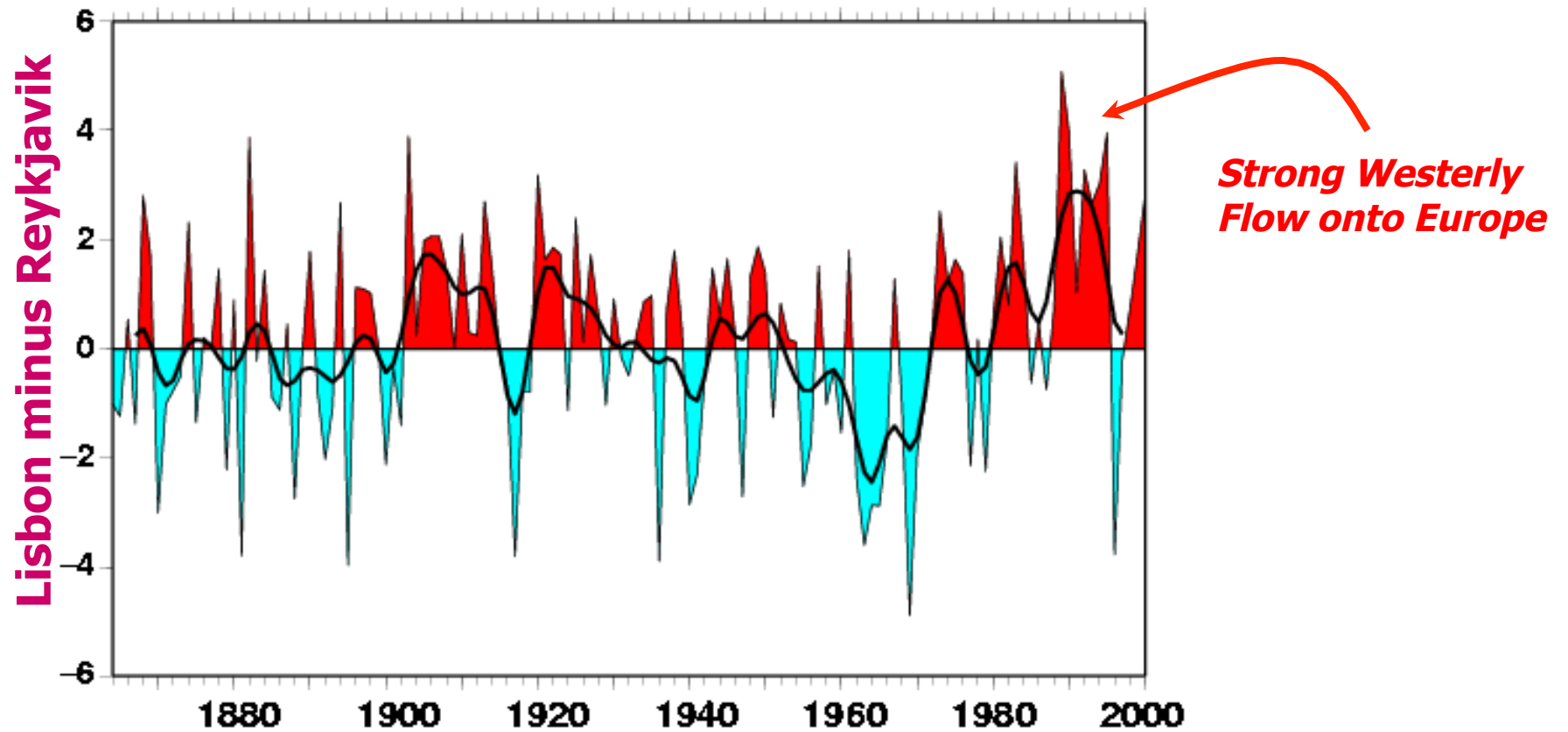


A Dominant Orchestrator of NH Weather and Climate

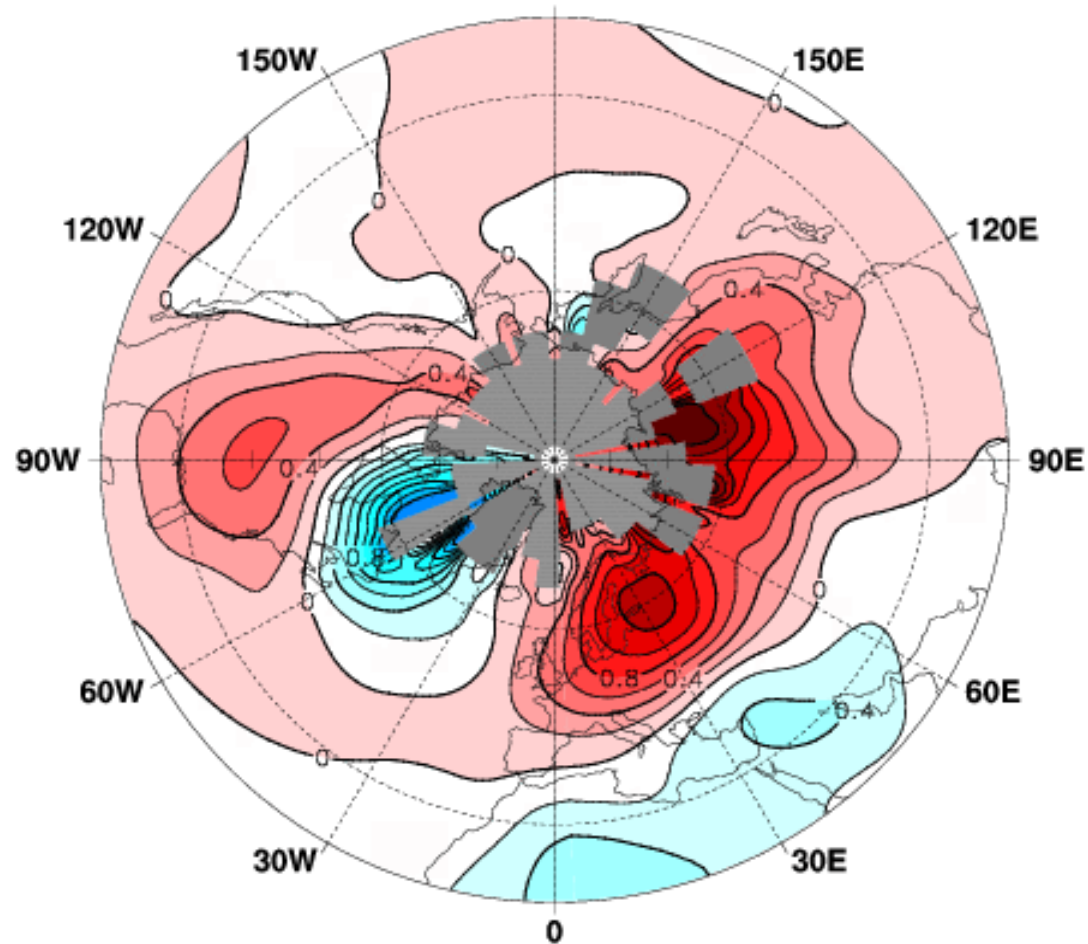
- Changes in mean wind speed and direction**
- Changes in number, intensity, paths of storms**
- Changes in moisture transport**

The North Atlantic Oscillation

Winter Index 1864-2000



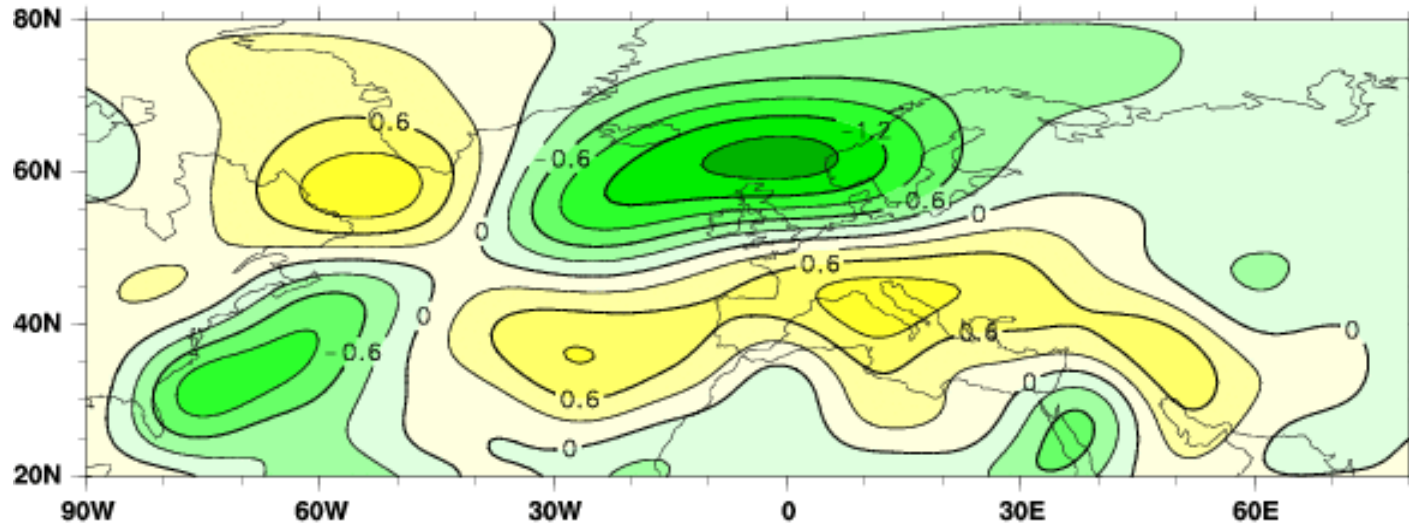
NAO Influence on Winter Surface Temperature



A substantial portion of the Northern Hemisphere warming in recent decades is associated with the upward trend in the NAO

The Earth's climate record includes both natural variability as well as human-induced effects

NAO Influence on Winter Precipitation



This pattern, together with the upward trend in the NAO, is consistent with observed changes in precipitation over the Atlantic basin

- **Advance of Scandinavian glaciers**
- **Retreat of Alpine glaciers**
- **Severe drought over parts of the Iberian peninsula**

Together with surface warming, there are significant impacts, e.g.

- **Agriculture (longer growing season)**
- **Energy supply/demand and water management**
- **Marine and terrestrial ecosystems**

Summary:

- What causes ENSO and how does ENSO affect global climate?
- What climate process dominates the N.H. winter climate variability on decadal scale? And how does it affect weather pattern?