

Climate Variability and Climate Change

1. Definitions

- The Climate System; Natural and Forced Variability

2. Natural Variability

- North Atlantic Oscillation, El Nino/Southern Oscillation

3. Forced Change (natural)

- Volcanic Eruptions (scattering particles)
- Changes in the Solar Luminosity

Climate
Variability

4. Forced Change (human)

- Burning of fossil fuels (increasing GH gases)
- Burning of biomass (scattering particles)

Climate
Change

1. Definitions:

• The Climate system

- What is included: the coupled atmosphere, ocean, land surface, and sea ice system
- What usually isn't included:
 - things that don't have much effect on the "climate system"
 - things that change on very long (geologic) time scales are usually considered external to the climate system
 - Examples: changes in location of continents and oceans, changes in land topography)

• Natural Variability

- Variations in climate that are due to *internal* interactions between the atmosphere, ocean, land surface and sea ice.
 - Examples: year-to-year differences in storminess in the Pacific Northwest, drought, the El Nino/Southern Oscillation (ENSO) phenomenon, the North Atlantic Oscillation, etc.

Climate Variability and Climate Change

1. Definitions

- The Climate System; Natural and Forced Variability

2. Natural Variability

- North Atlantic Oscillation, El Nino/Southern Oscillation

3. Forced Change (natural)

- Volcanic Eruptions (scattering particles)
- Changes in the Solar Luminosity

4. Forced Change (human)

- Burning of fossil fuels (increasing GH gases)
- Burning of biomass (scattering particles)

Agents of Climate *Change*: Forcing

Climate can change due to *external forcing*

• Natural Forcing

- Examples:
 - Volcanoes (scattering particles α)
 - changes in the Earth's orbit
 - changes in the solar luminosity (S_0)

• Human Forcing

- Examples:
 - emissions of greenhouse gases (ϵ)
 - aerosols (tiny particles α)
 - land use changed (albedo α , etc)

“Radiative Forcing”

- **Radiative Forcing** (RF) is a measure of the change in the energy balance of the Earth-atmosphere system when factor(s) that affect climate are altered. (IPCC '07)
 - The RF is calculated instantaneously to the alteration (ie, before the atmosphere adjusts to the change)
 - Called ‘radiative’ because the process that communicates the net change in energy is electromagnetic radiation
- A positive Radiative Forcing results in a net increase in downward energy and thus will lead to a warming of the surface. Examples of RF:
 - increase in the solar luminosity
 - increase in greenhouse gas concentration
- RF allows one to assess and compare the relative importance of different natural and human-induced forcings on climate

Climate Variability and Climate Change

1. Definitions

- The Climate System; Natural and Forced Variability

2. Natural Variability

- North Atlantic Oscillation, El Nino/Southern Oscillation

3. Forced Change (natural)

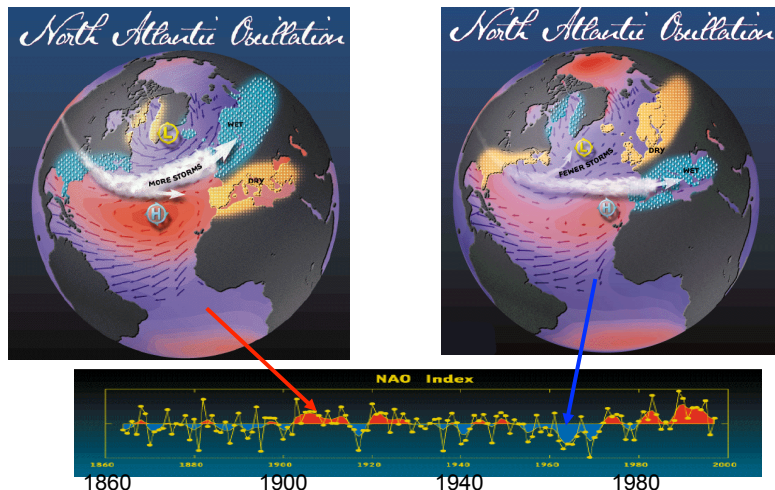
- Volcanic Eruptions (scattering particles)
- Changes in the Solar Luminosity

4. Forced Change (human)

- Burning of fossil fuels (increasing GH gases)
- Burning of biomass (scattering particles)

2. Examples of Natural Variability

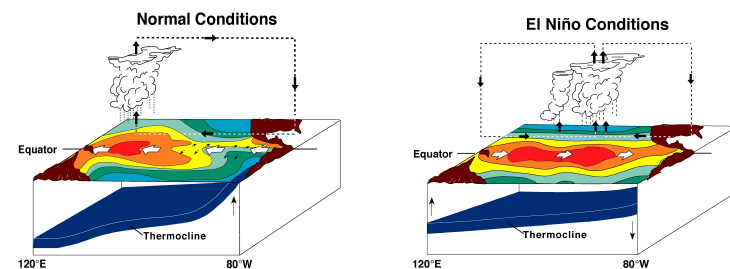
- The North Atlantic Oscillation (NAO)
 - (year to year variations in the wintertime storminess in the N. Atlantic)



2. Examples of Natural Variability

El Nino/Southern Oscillation (ENSO)

- El Nino/Southern Oscillation(ENSO) is the dominant pattern of climate variability on year-to-year time scales



- The physics responsible for ENSO are localized in the tropical Pacific, but ENSO causes global climate anomalies

ENSO

Changes in the distribution of sea surface temperature are coordinated with changes in atmospheric circulation and rainfall patterns;

