Climate Variability and Change

Natural and Human-induced

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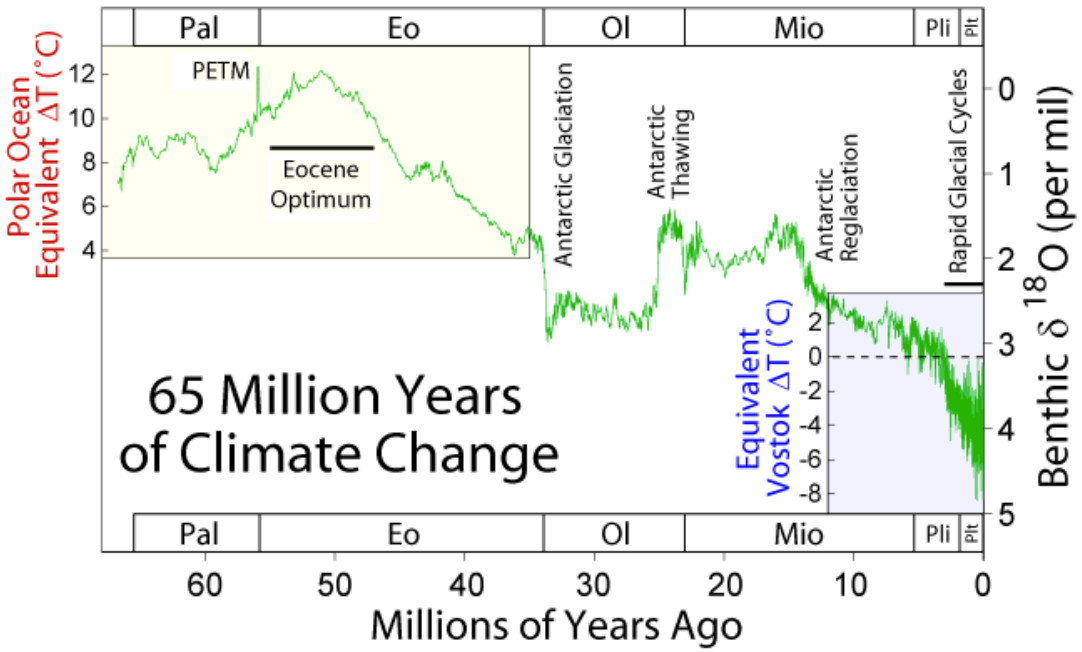
Natural Variability

Climate change is a natural phenomenon. Even if human activity were not a factor, climate would still fluctuate at various scales and timelines due to a number of factors.



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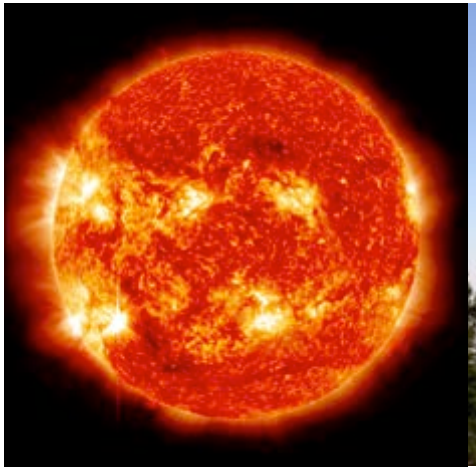
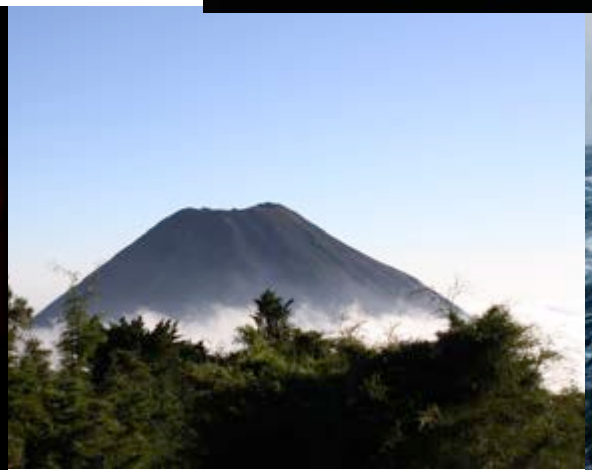
What Causes Climate to Vary?

- Solar radiation
  - Sun's variability
  - Earth's orbit and tilt
- Tectonics
- Atmospheric changes
  - Volcanic eruptions
  - Gas release/uptake
- Oceanic changes





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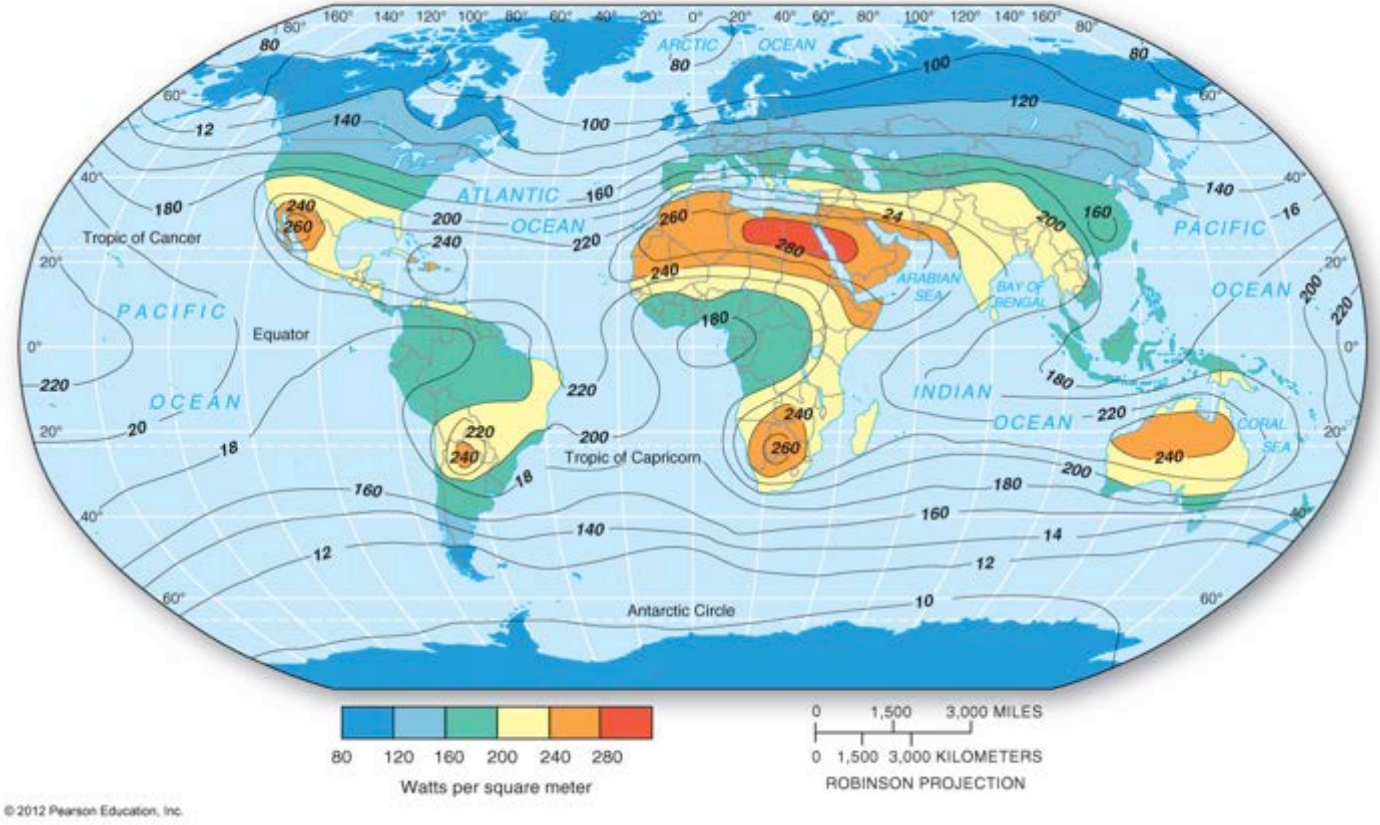
Solar Radiation (Insolation)

Related to orbit tilt/but also to sunspot activity, atmospheric conditions, and surface type



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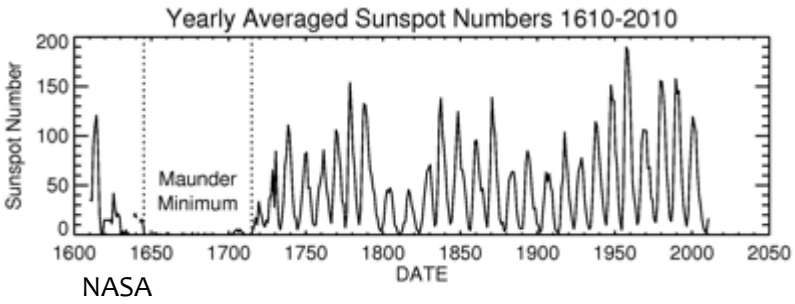
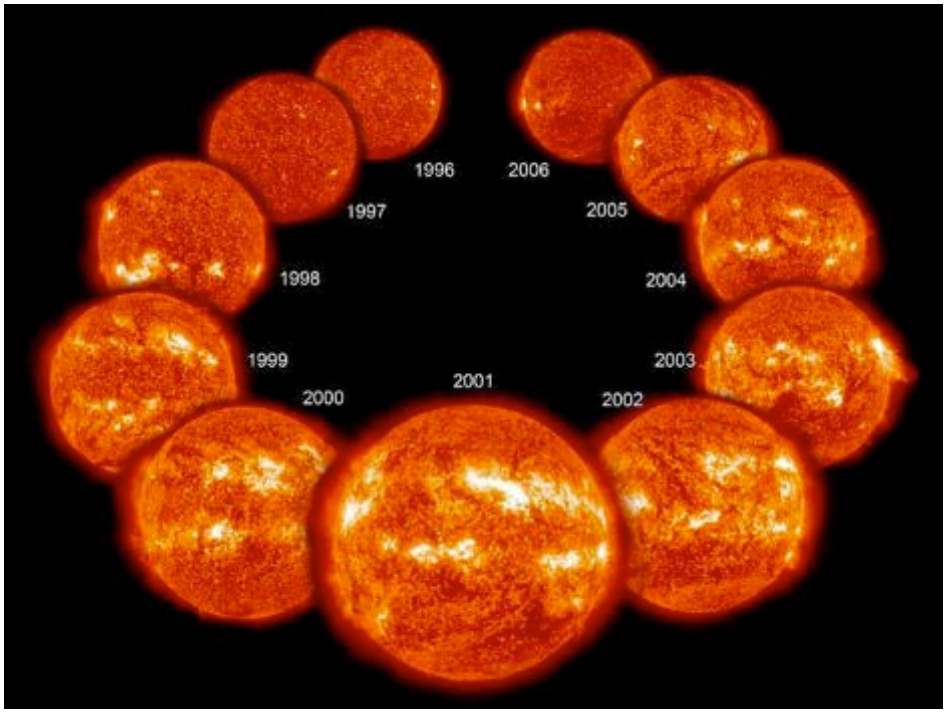
Solar Variability

- The sun's magnetic activity varies
  - 11 year sunspot cycle



NASA



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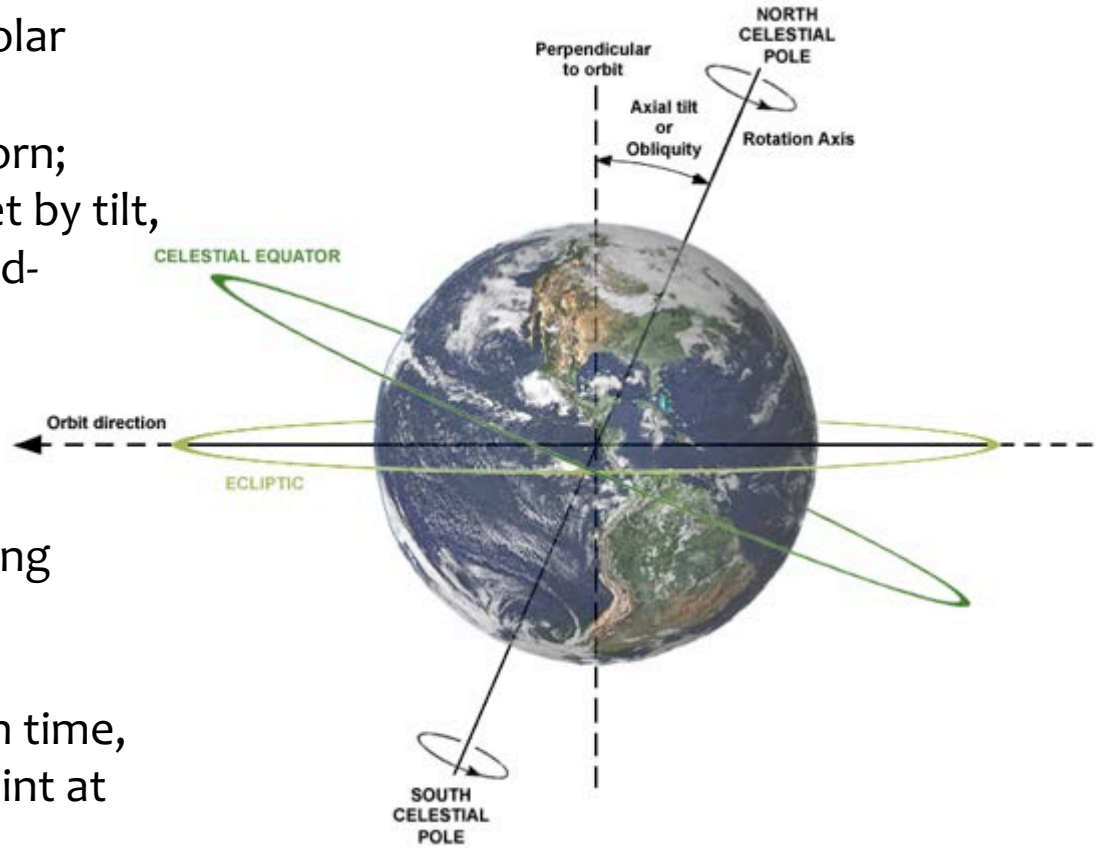
Earth's Tilt

- The reason we have seasons!
- Large effect on which areas get solar radiation and what time of year
  - Tropics of Cancer and Capricorn; Arctic and Antarctic circles set by tilt, which primarily influences mid-latitude and polar regions
- Obliquity – change in tilt
  - 22.1°-24.5°
  - ~41,000 years
  - Currently 23.44° and decreasing
- Precession of the equinoxes
  - Axial precession
  - Rotation of axis changes with time, north pole doesn't always point at north star
  - Changes every 26,000 years



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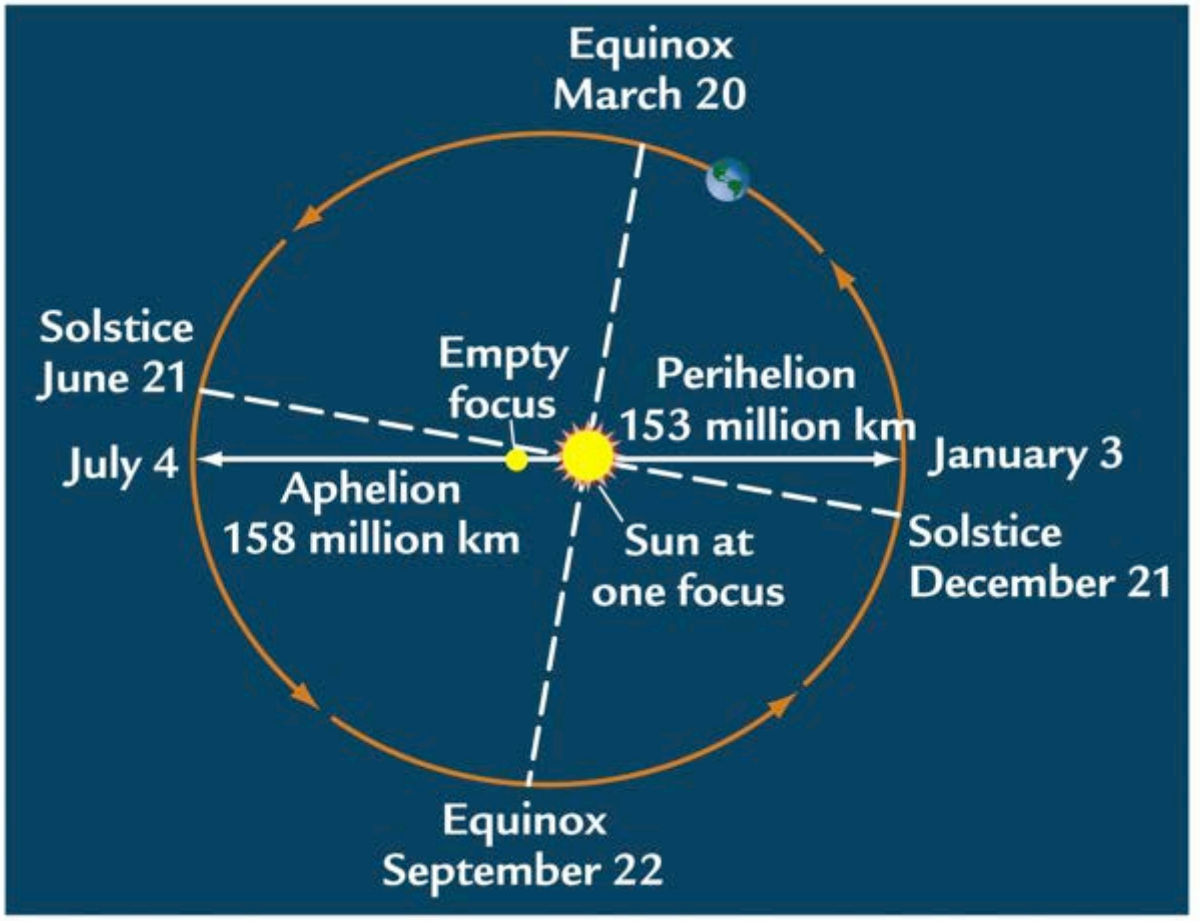
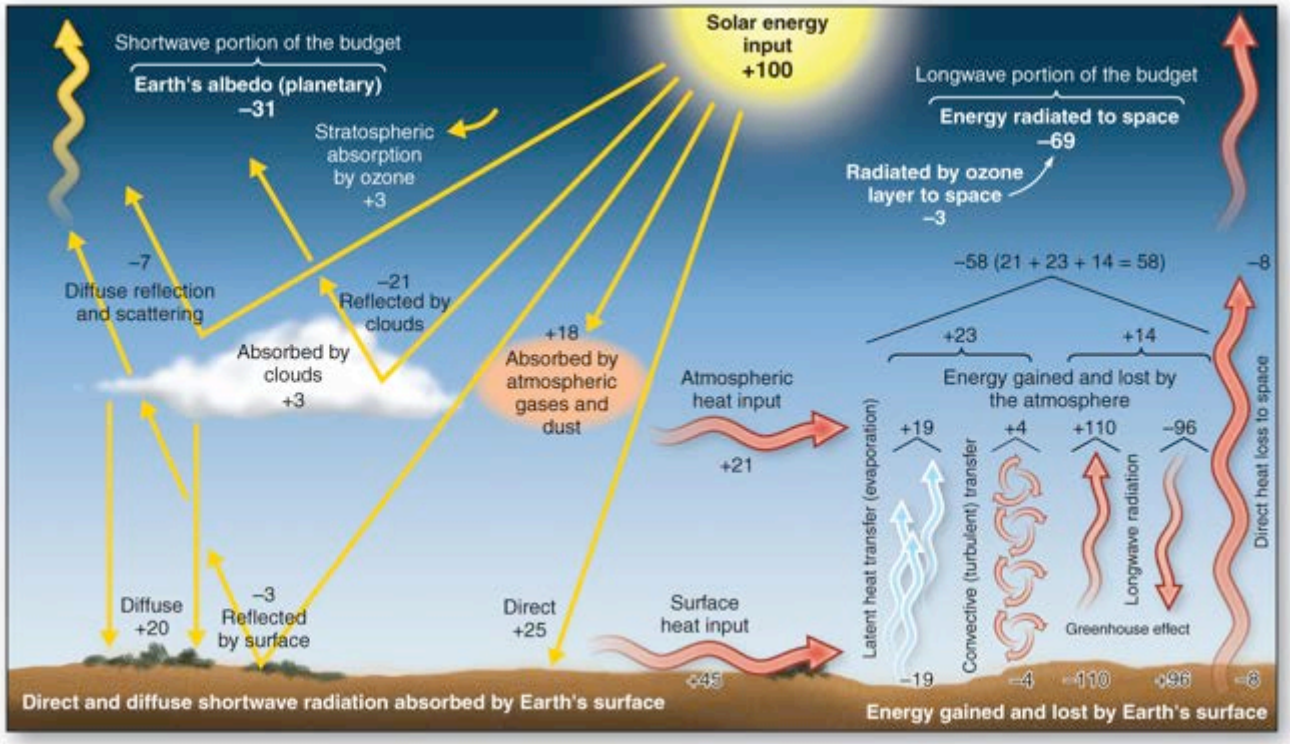
Earth's Orbit

- Not circular, but oval
- Precession – change in timing nearest and furthest points from sun
  - ~22,000 years
- Eccentricity – change in shape of Earth's orbit
  - ~100,000 years



Energy Balance

Lighter surfaces will reflect more energy, darker will absorb more



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Albedo and Sea Ice

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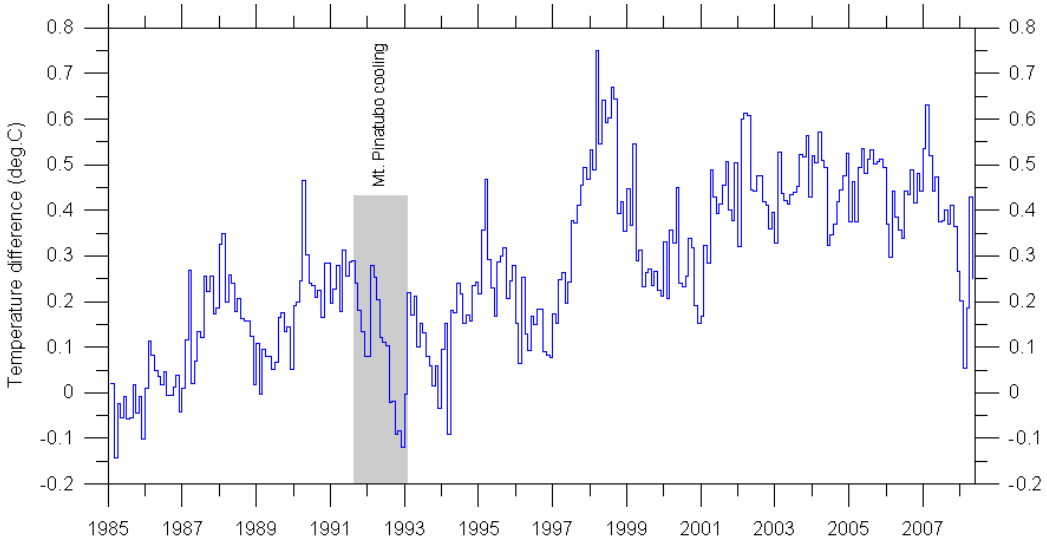
Tectonics

- Longer and shorter scale
  - Longer (millions of years) – uplift and subsidence
  - Shorter (our focus) – volcanoes
    - ex: Mt Pinatubo 1991



http://www.climate4you.com/ClimateAndVolcanoes.htm#Mount Pinatubo 1991

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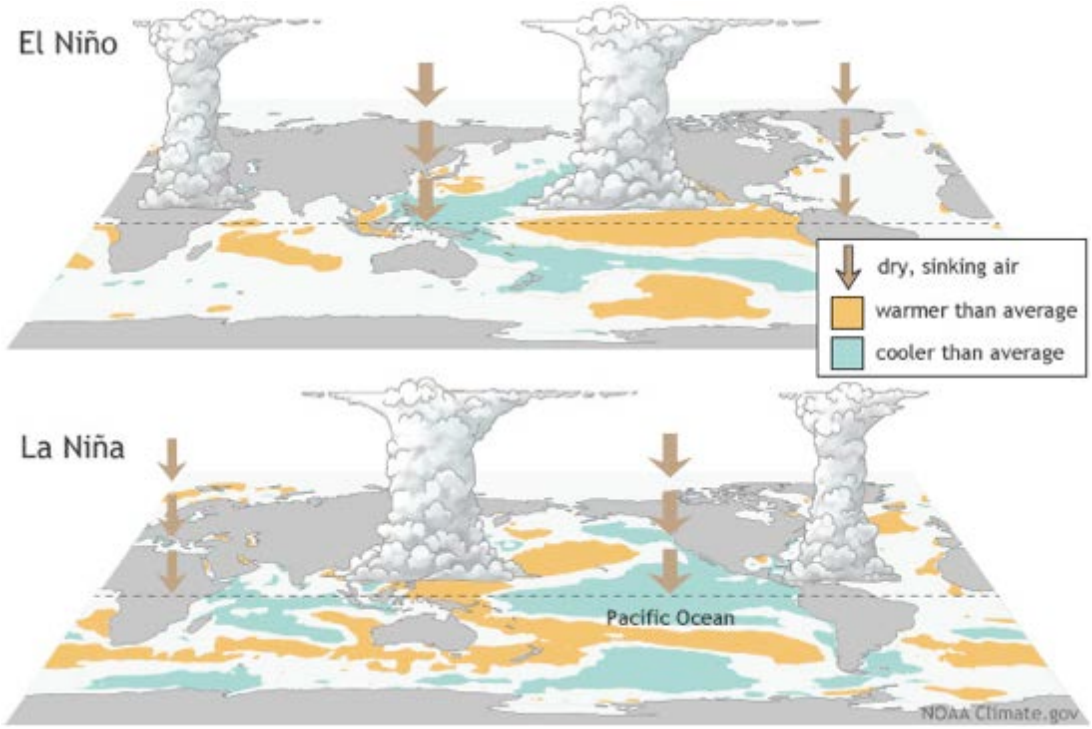
Atmospheric Changes

- Can be short or long term
  - "Teleconnections"
    - Changes in wind/water system
    - Example: El Niño
      - Decrease in easterlies off of west coast of Peru
  - Compositional changes
    - Caused by volcanoes, plant/animal life, etc.



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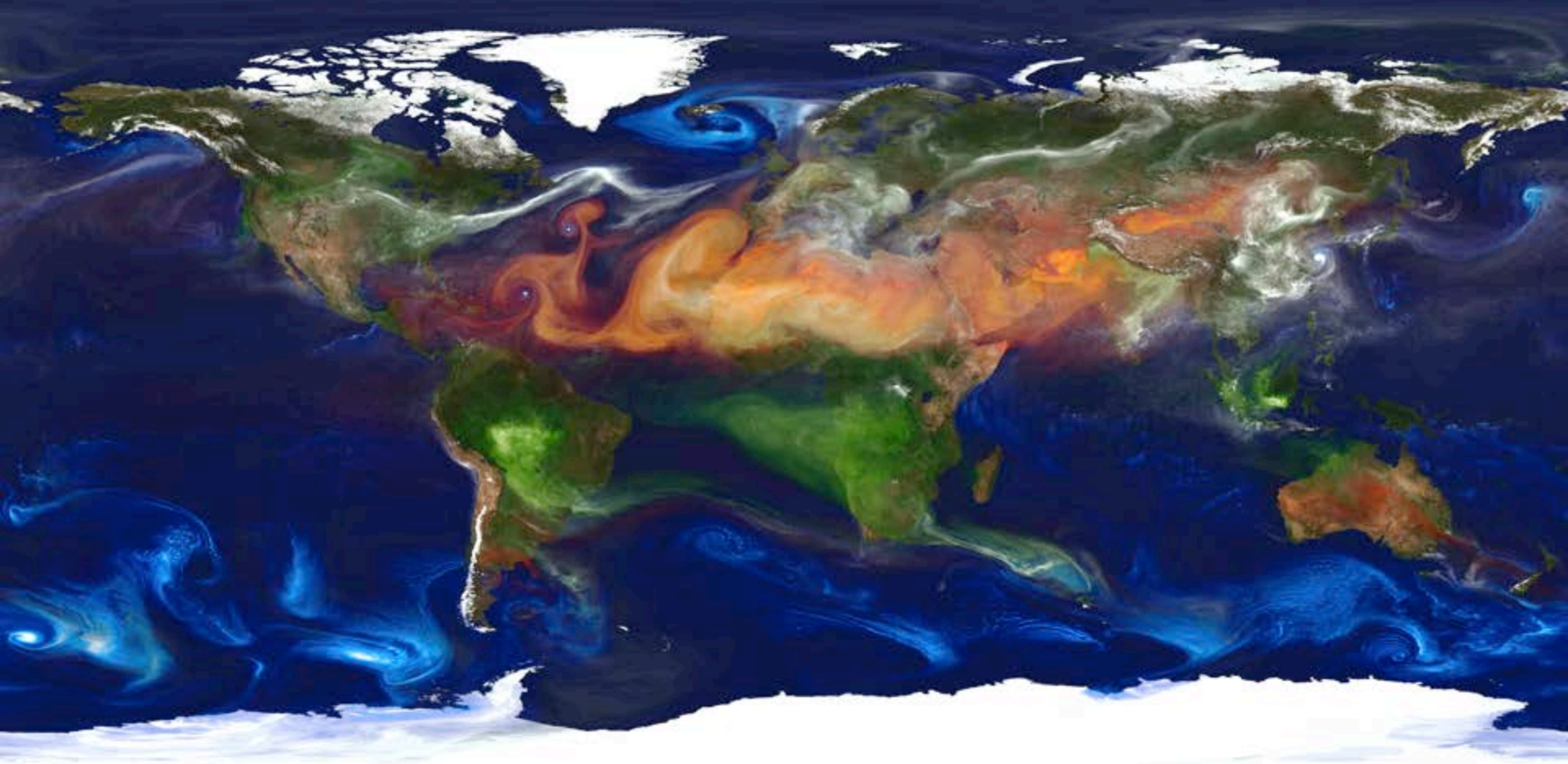

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Example of different aerosols

Dust (red) is lifted from the surface, sea salt (blue) swirls inside cyclones, smoke (green) rises from fires, and sulfate particles (white) stream from volcanoes and fossil fuel emissions.

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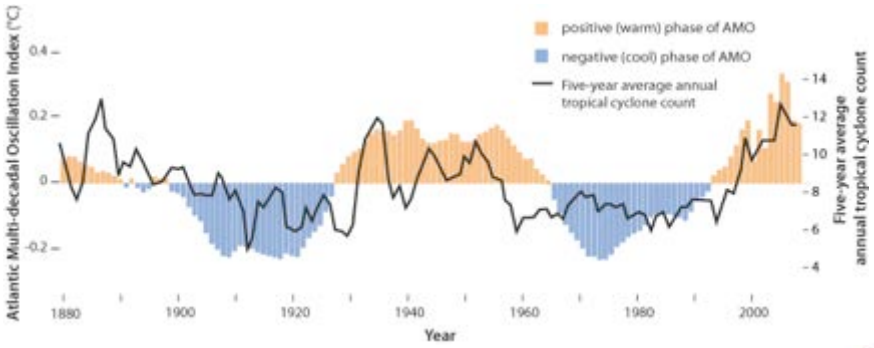
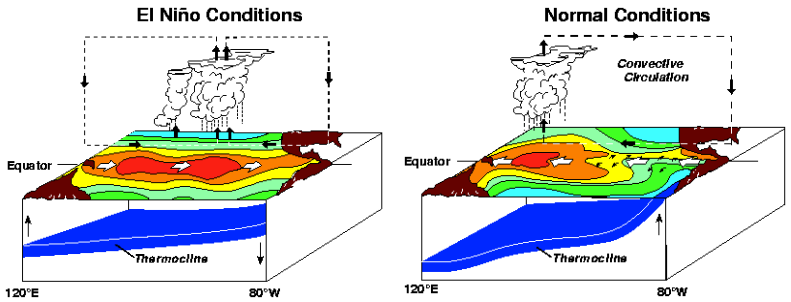
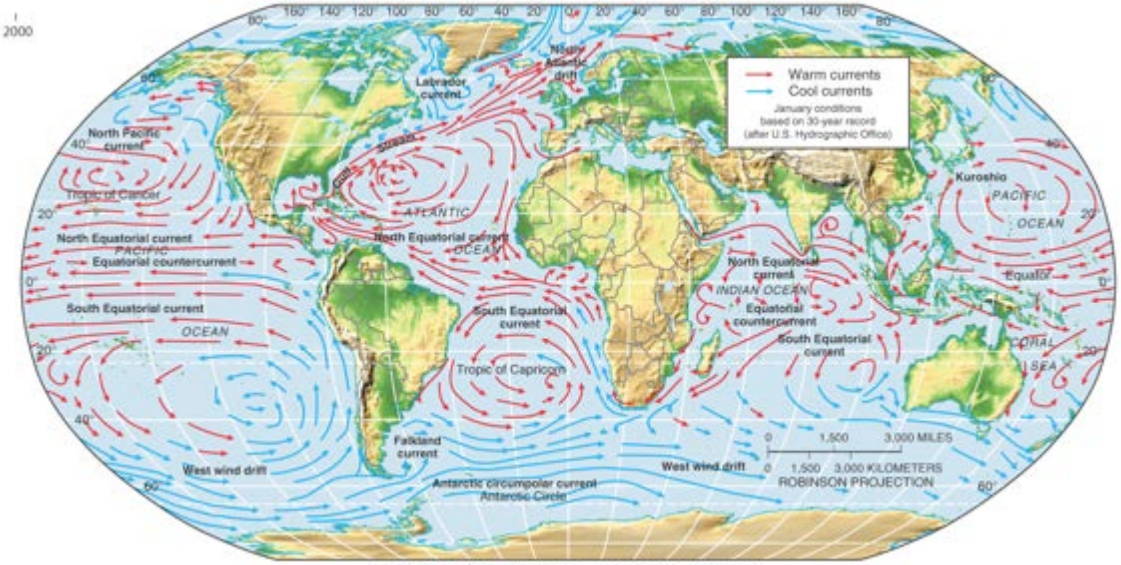
Oceanic Changes



Changes in ocean circulation, composition





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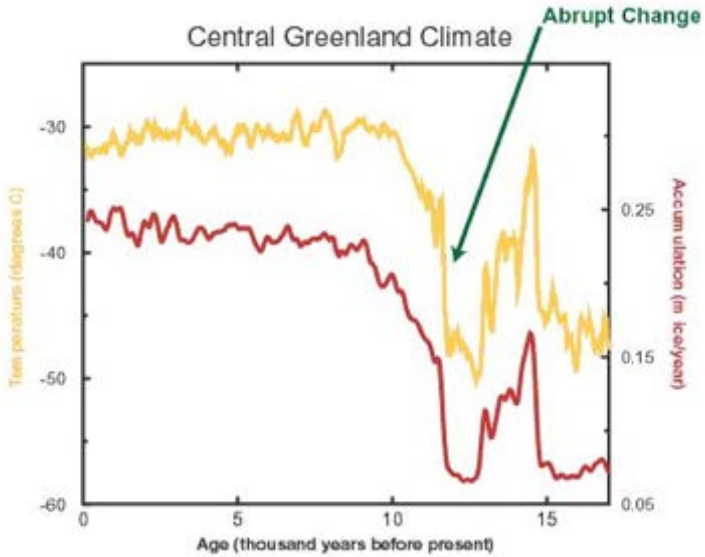
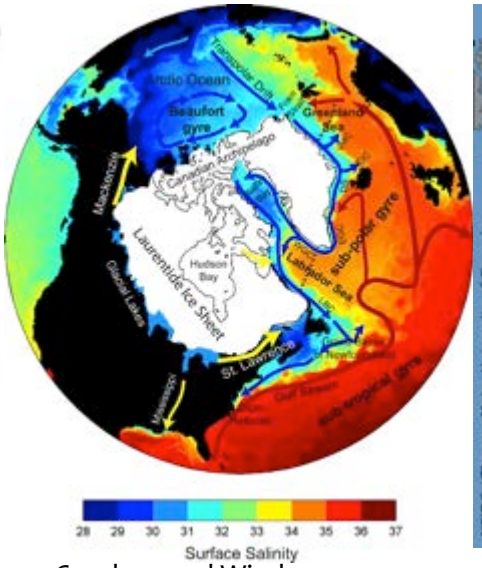
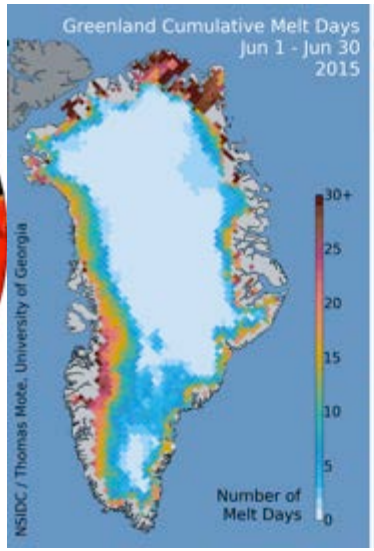
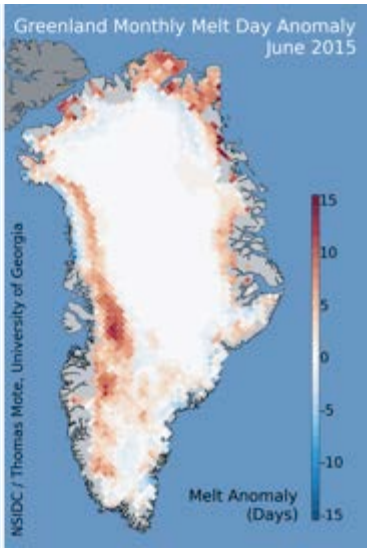


http://www.ldeo.columbia.edu

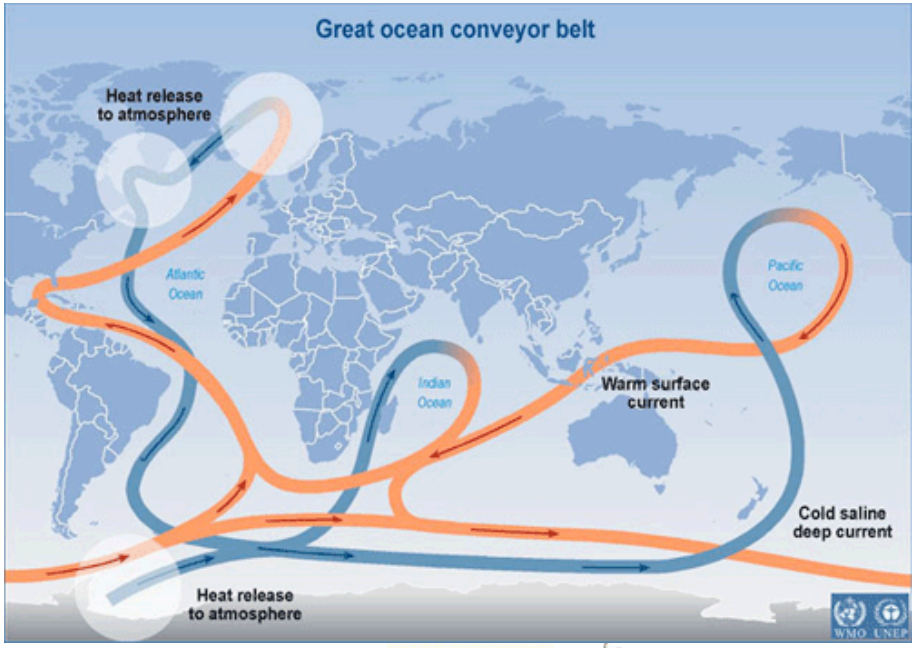


Condron and Windsor 2012





- Increased heat and/or freshwater influx can disrupt ocean circulation
  - Can be caused by biological, tectonic, climatic factors



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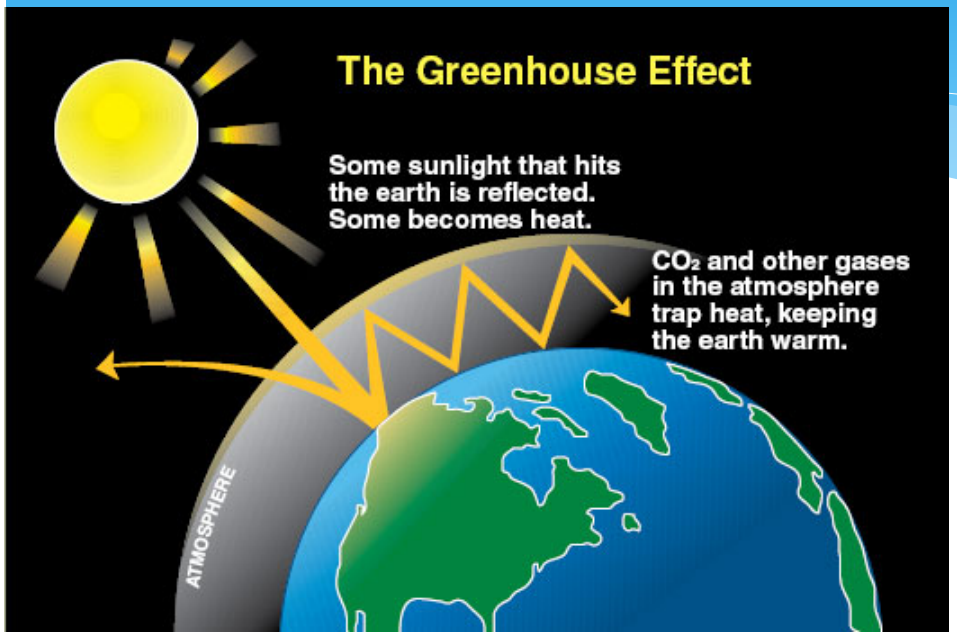
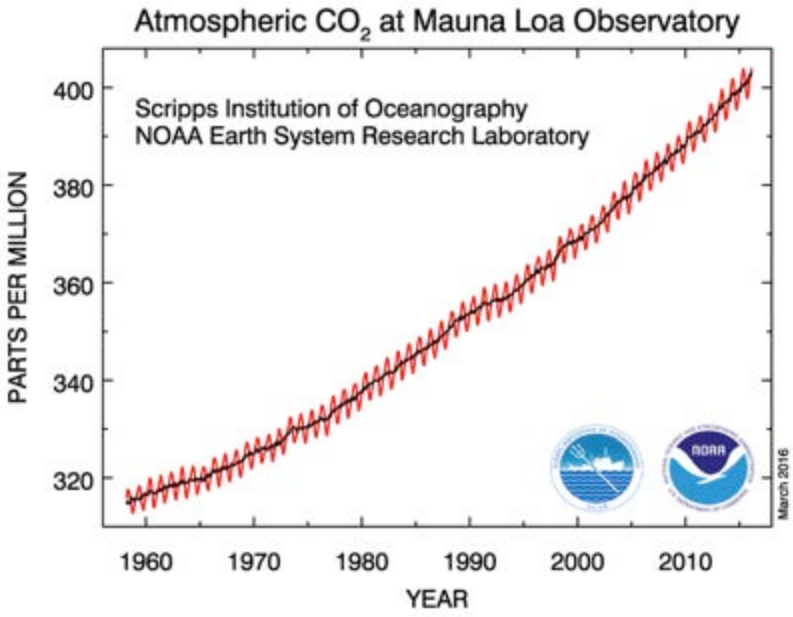
Greenhouse Gas Effect



Washington Department of Ecology

Gases (CO_2, CH_4, H_2O and others) that trap heat in atmosphere have been increasing since at least the "industrial revolution" in 19th century.



Increasing in CO_2 since the industrial revolution is linked to increasing temperature. On May 9, 2015, CO_2 passed 400 ppm for the first time since observations started.

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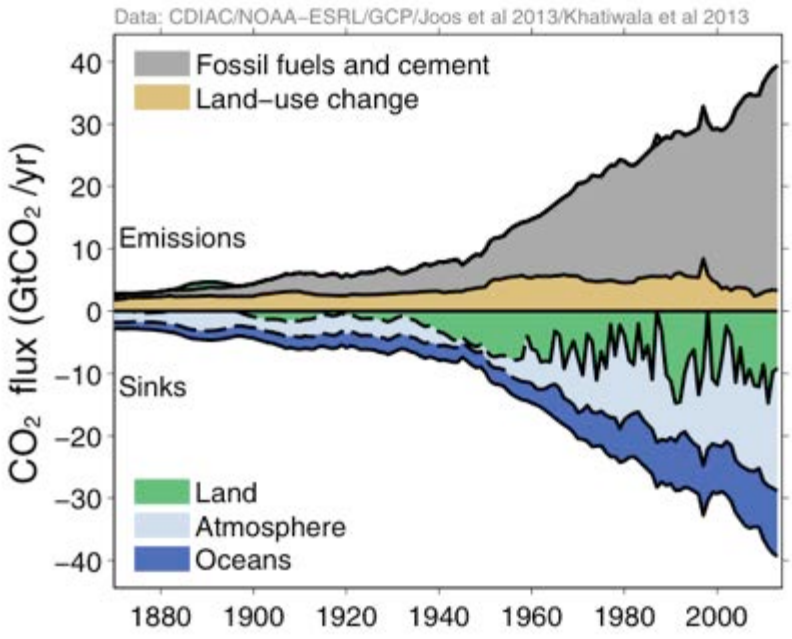
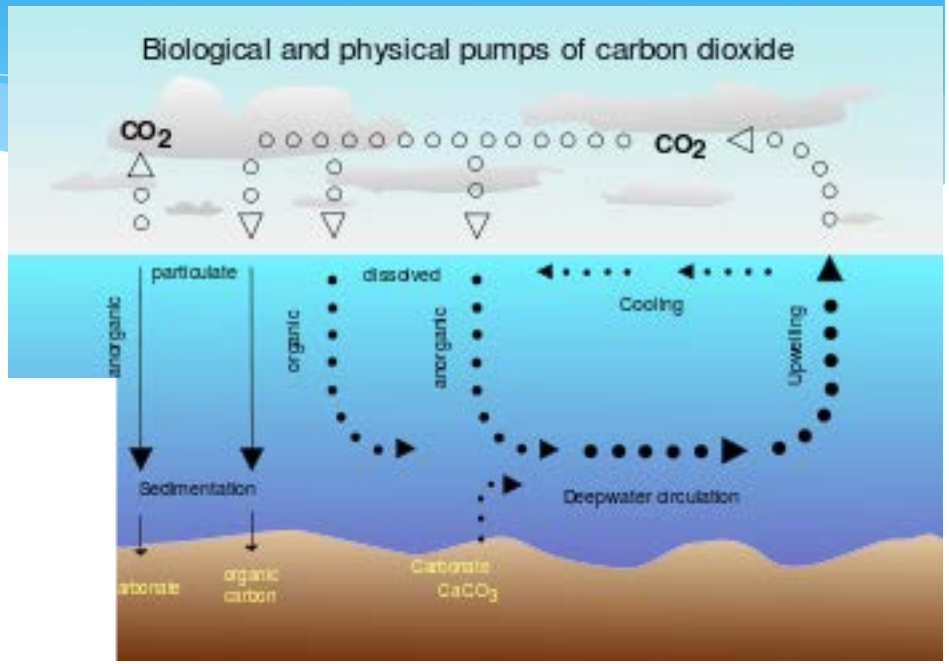
Carbon Sinks and "Pumps"

- Primarily Forests and Deep Oceans
- Key part of natural carbon cycle
- Act to move, trap CO_2





However, human activity has been outpacing storage, or has caused dangerous changes (ocean circulation, deforestation)

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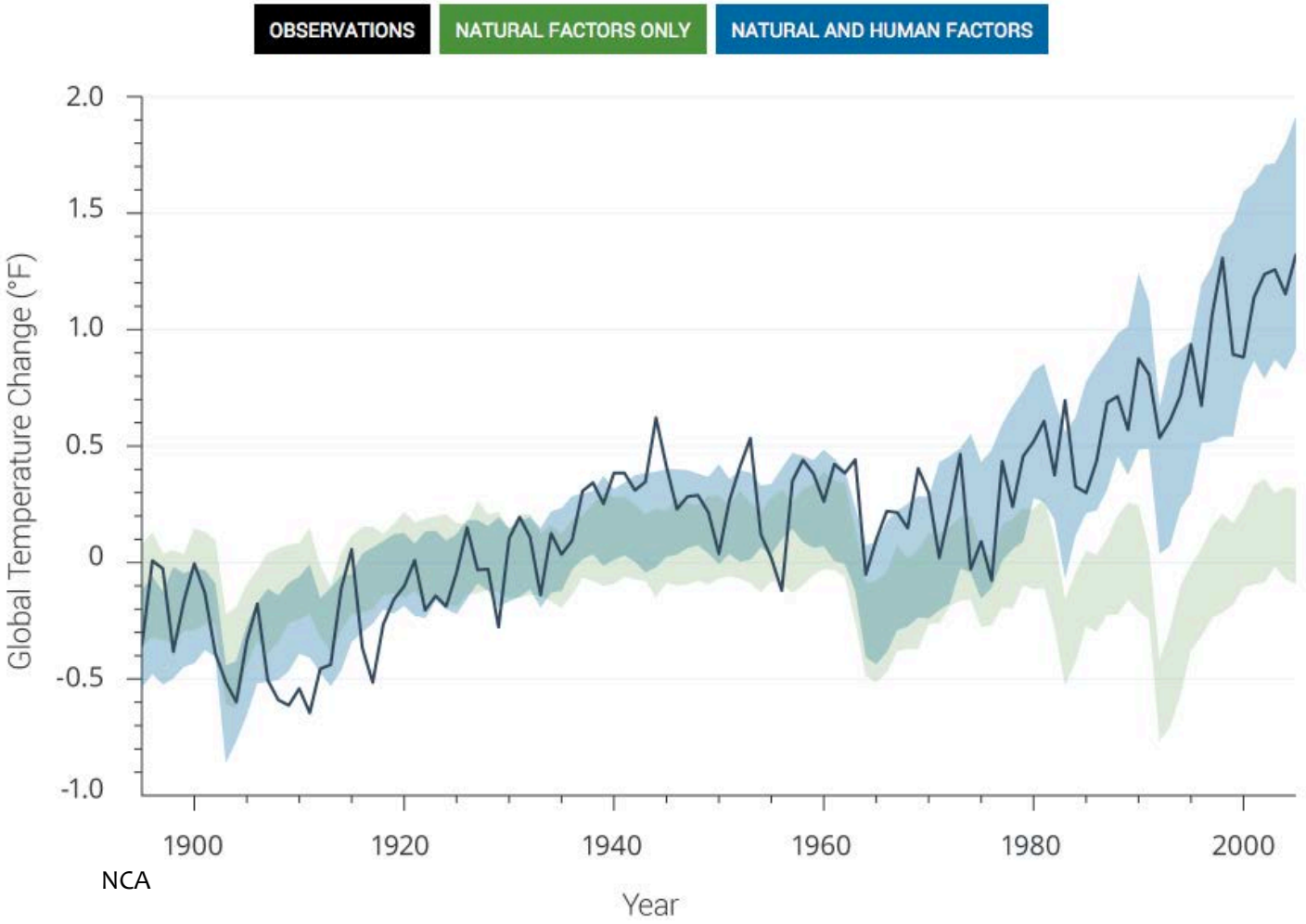
Human – Induced Change



NCA

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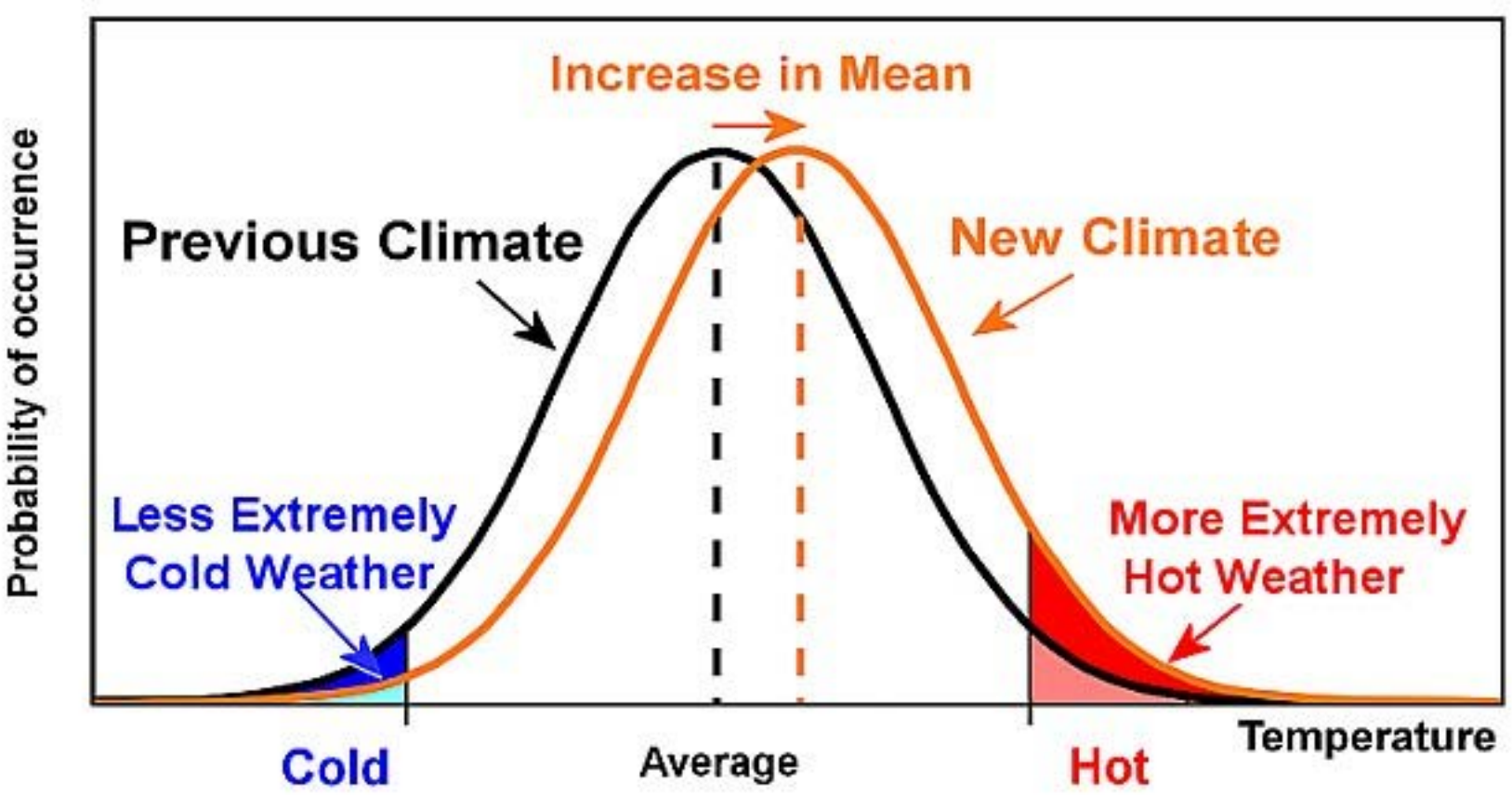
Future Climate Change



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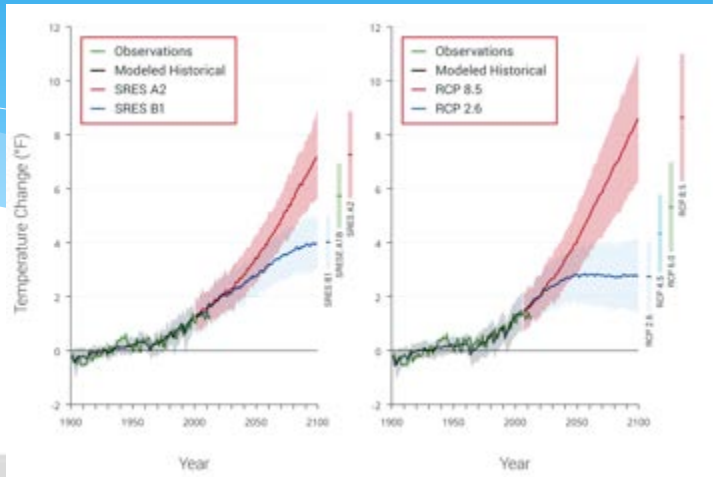
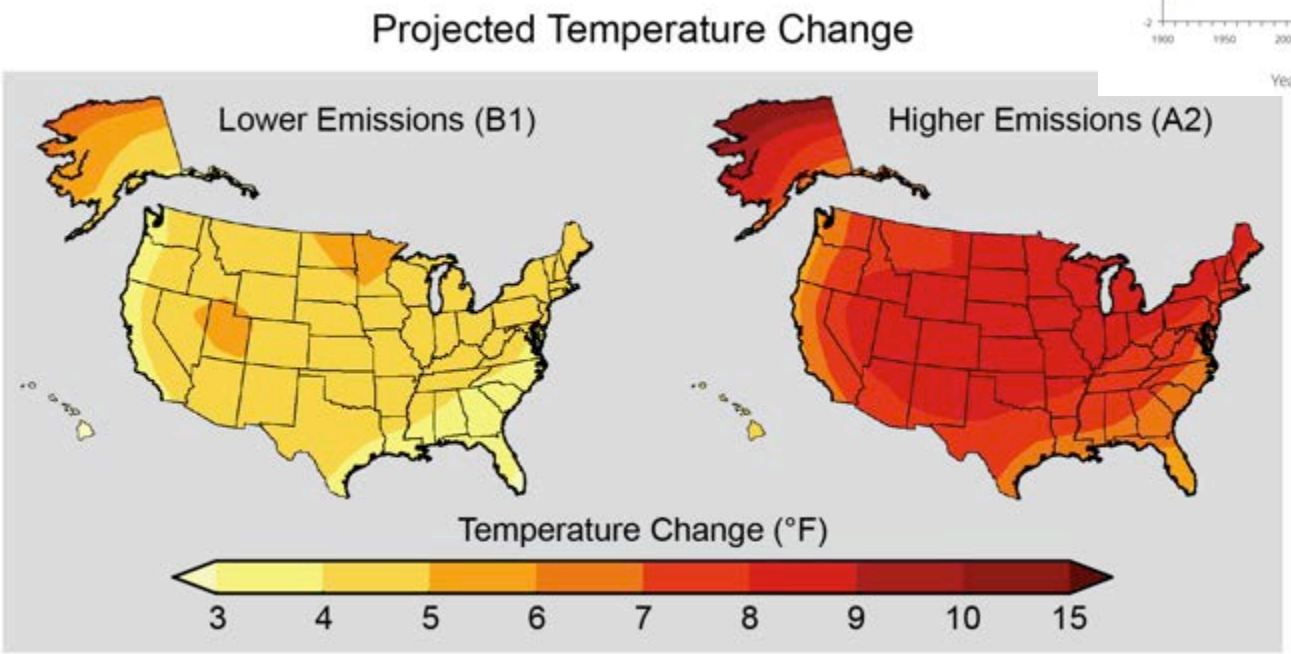
Projections

If no changes are made to reduce human impact, we will see a major change in "normal" climate (has already started)





Will cause more extreme fluctuation

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