



Arab Academy for Science, Technology, and Maritime Transport (AASTMT)
Cairo Campus
College of Computing and Information



UNR1601

Climate Change and Water Management

Ch [02] – Climate Change

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Climate Variability

- ***Climate variability*** refers to variations in the mean state and other statistics (such as the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events.
- ***Variability*** may be due to
(***internal variability***) : *natural internal processes within the climate system*
or to (***external variability***) : *variations in natural or anthropogenic external forcing*



What is climate change?

- **Climate change** is
a change in the pattern of weather,
and related changes in oceans, land
surfaces and ice sheets, **that have come to
define Earth's local, regional and global
climates and occurring over time scales of
decades or longer.**



Energy Balance

The temperature of the Earth is determined by a **balance of the energy entering the Earth–atmosphere system and the energy leaving the system.**

Global energy balance (GEB):

Earth's stored energy =

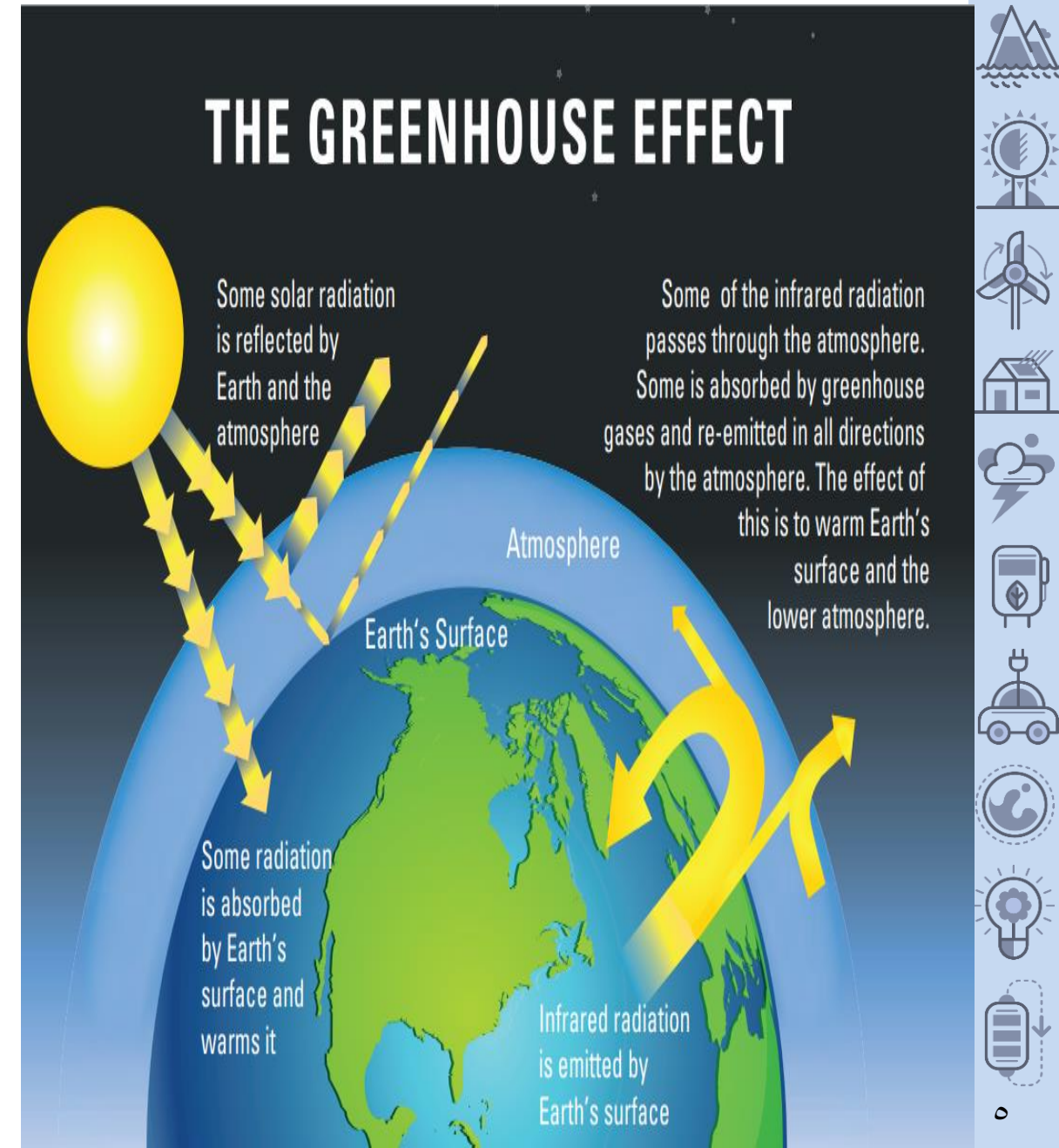
Energy the earth receives from the Sun - Energy the earth releases to space.



The greenhouse effect

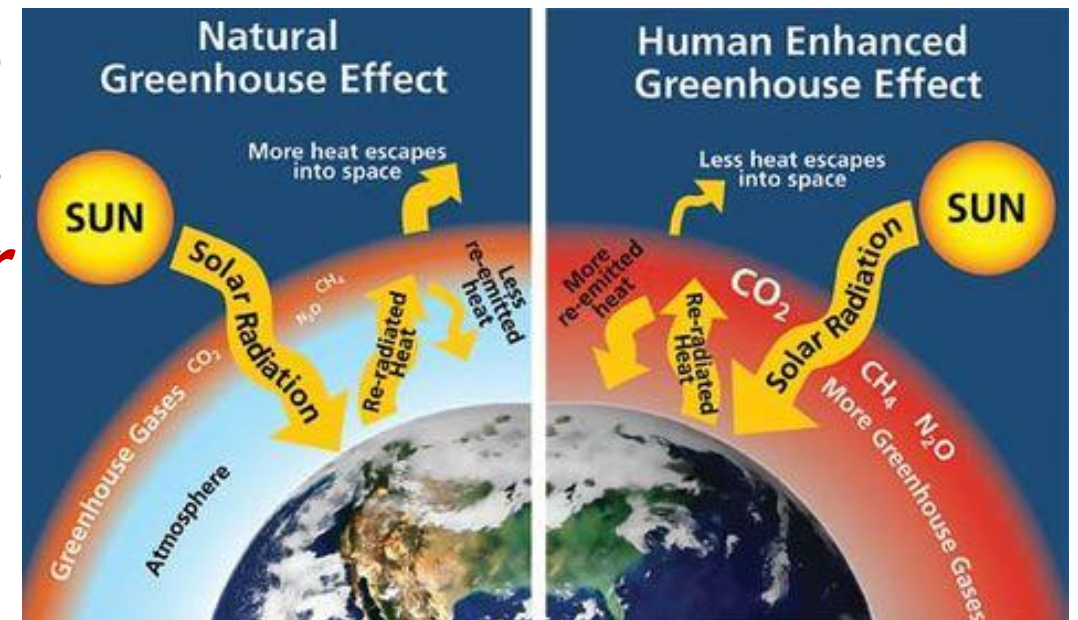
Greenhouse **gases** in the atmosphere, including **water vapour**, **carbon dioxide**, **methane**, and **nitrous oxide**, absorb heat energy and emit it in all directions (including downwards), keeping Earth's surface and lower atmosphere warm.

*Adding more greenhouse gases to the atmosphere enhances the effect, **making Earth's surface and lower atmosphere even warmer.***



Climate Forcing

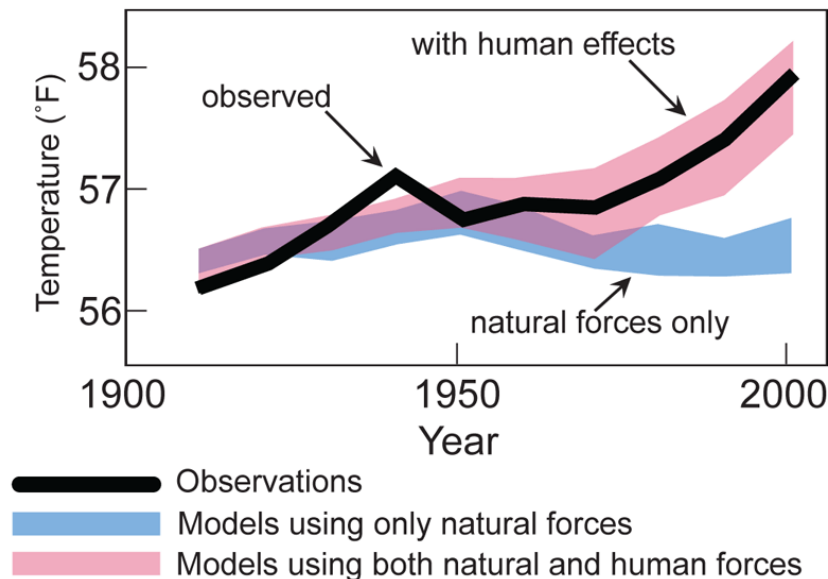
- Any **process or activity** that influences the GEP either by increasing or decreasing the earth's stored energy contributes to climate change and is qualified to be called a **climate forcing process**.
- Climate forcing* as an imbalance in energy at the top of the Earth's atmosphere either ***externally or by human activities***.



Climate Forcing

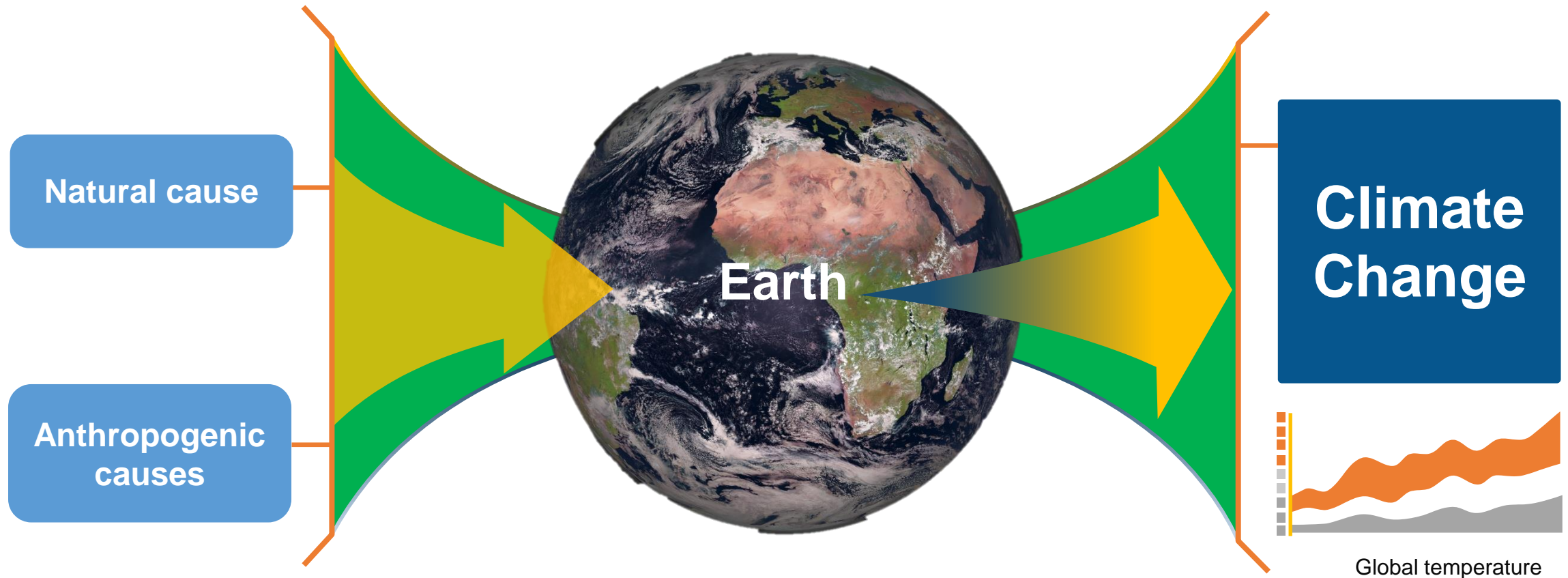
Climate forcing processes are classified as:

- **Internal Climate Forcing Processes** - **processes operating on the GEB from within the earth.**
- **External Climate Forcing Processes** - **processes operating on the GEB from outside the earth.**



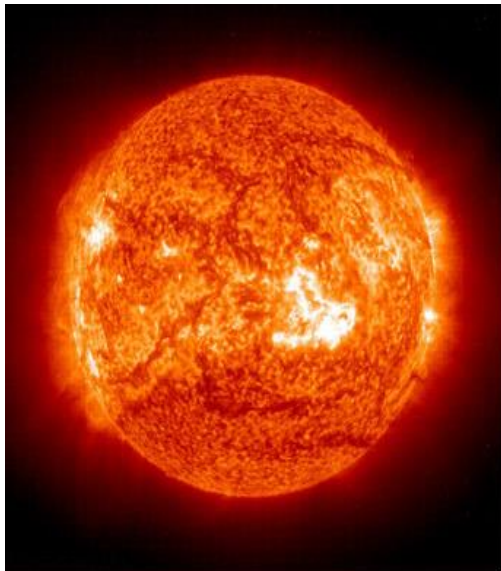
Climate Change

The internal and external climate forcing processes *except the man-made processes* are grouped together as *natural causes of climate change*.



External Climate Forcing Processes

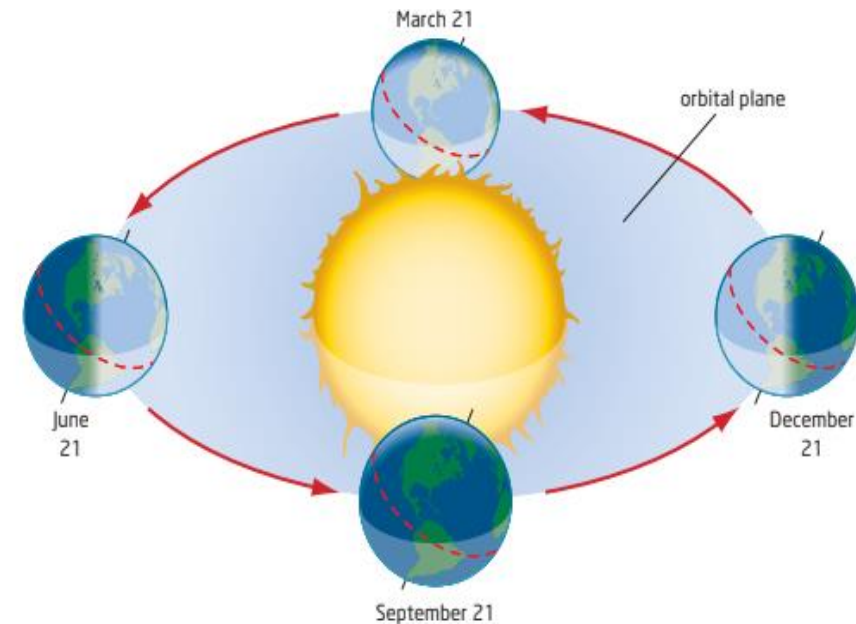
- 1- Variations in the amount of energy received from the sun.
- 2- Variations in the earth's orbit around the sun.



Solar Maximum (February 22, 2002)



Solar Minimum (May 10, 2008)



Internal Climate Forcing Processes

1. Oceans
2. Continental Drift
3. Atmosphere
4. Water Cycle
5. Clouds
6. Ice and Snow
7. Land Surfaces
8. Volcanic Eruptions
9. Human Causes

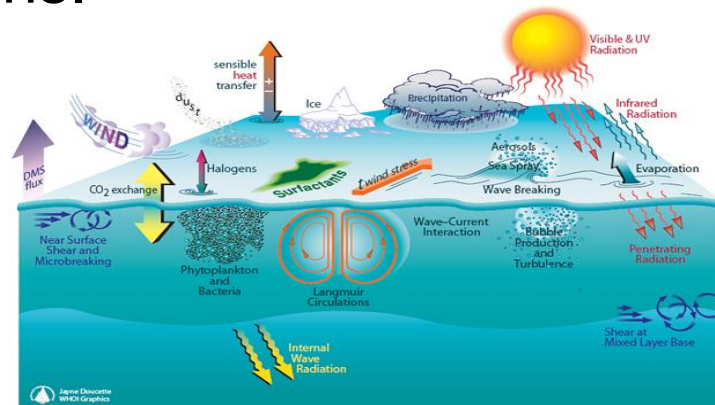


Internal Climate Forcing Processes

1. Oceans

- Oceans are the **key source of moisture** in the air through interactions with the atmosphere.
- Oceans also **store heat efficiently**, transporting it thousands of miles thus redistributing heat in time and space.
- The oceans and **marine life** also **consume huge amounts of carbon dioxide**.

These ocean-based processes exert tremendous influence on global climate and accounts for the variations.

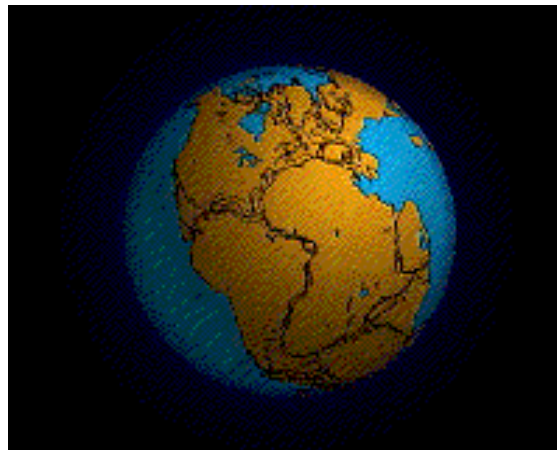


Internal Climate Forcing Processes

2. Continental Drift

Scientists believe that our **earth is still slowly drifting** and constantly changing. This constant drifting is believed to have impact on the climate **because it changes the physical features of the landmass**, their position and the **position of water bodies**.

The separation of the landmasses **changed the flow of ocean currents and winds, which affects the climate.**



Internal Climate Forcing Processes

3. Atmosphere

- The **atmosphere** **stores** *a lot of heat or energy which comes from the sun*. This energy regulates the earth's climate.
- The atmosphere **composes of small particles and several gases** out of which are the green house gases (GHGs) that store heat. *The small particles (aerosols) tend to block sunlight* reaching the earth.

4. Water Cycle

- Higher air temperatures can **increase** **water evaporation and melting of ice**.
- Water vapour is *the most potent greenhouse gas*.
- Clouds also affect evaporation, *creating a cooling effect*.



Internal Climate Forcing Processes

5. Clouds

- Clouds reflect solar energy (*cooling* the earth) and thereby trapping heat being radiated up from the surface (*warming* the earth).
- Clouds **variability contribute** to climate change.

6. Ice and Snow

- The **whiteness of ice** and snow reflects heat out, *cooling* the planet.
- When **ice melts into the sea**, this **drives heat from the ocean causing variability in climate**.



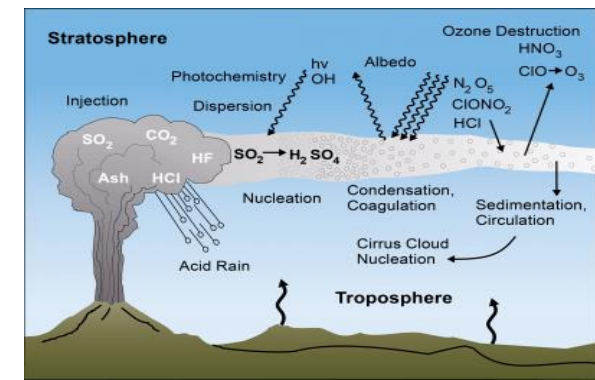
Internal Climate Forcing Processes

7. Land Surfaces

- **Mountain** ranges can block **clouds**, creating "dry" shadows downwind.
- **Sloping** land allows **more water runoff**, leaving the land and air drier.
- **A tropical forest** will soak up carbon dioxide, but once cleared for cattle ranching, the same land becomes a source of methane, a greenhouse gas.

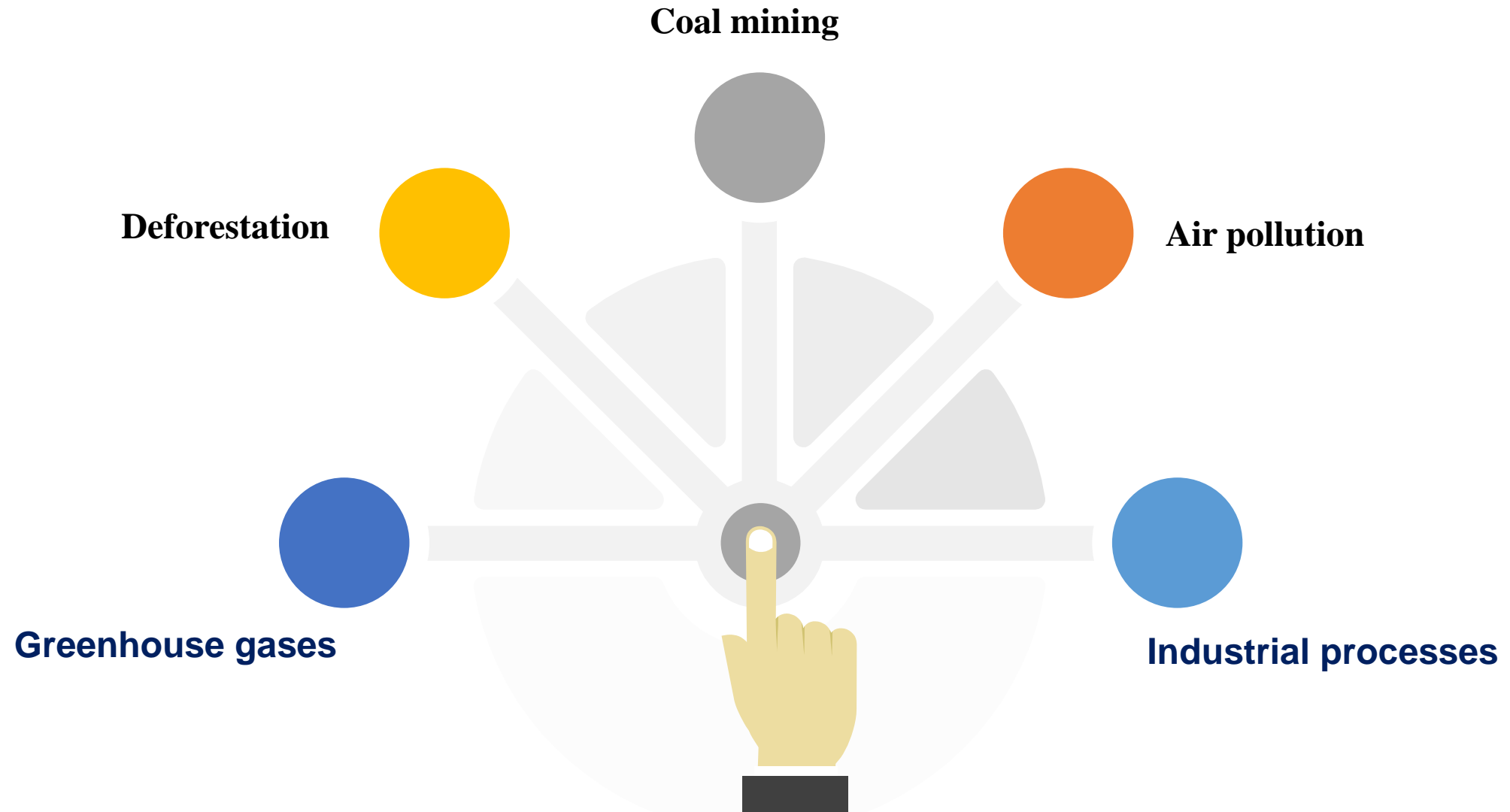
8. Volcanic Eruptions

- A volcanic eruption **emits** large volumes of **sulphur dioxide** (SO_2), **water vapour**, **dust**, and **ash** into the atmosphere that influence climatic patterns for years. The gases and dust particles partially block the incoming rays of the sun, leading to cooling.



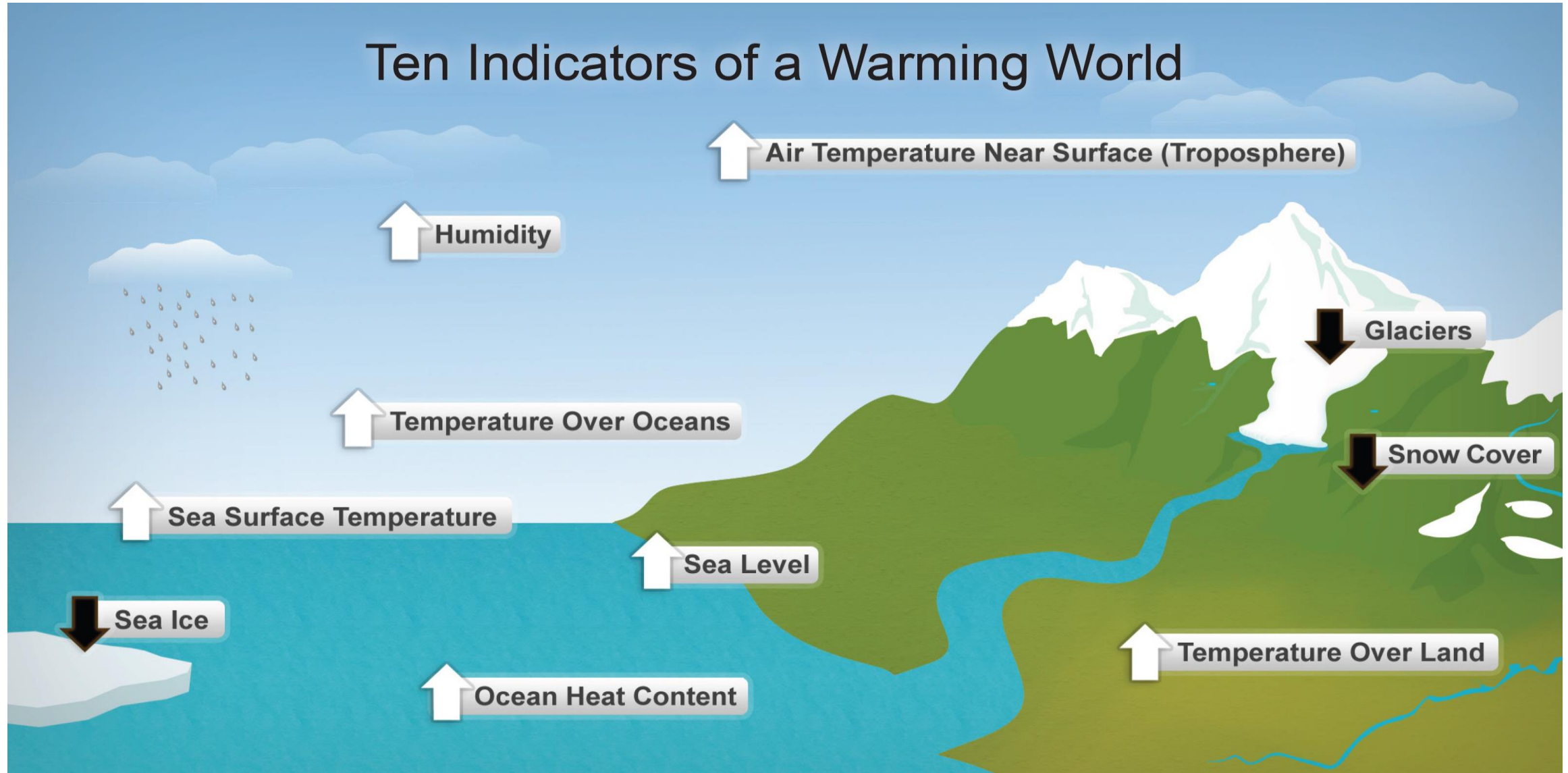
Internal Climate Forcing Processes

9. Anthropogenic or human causes



Main indicators of climate change (10)

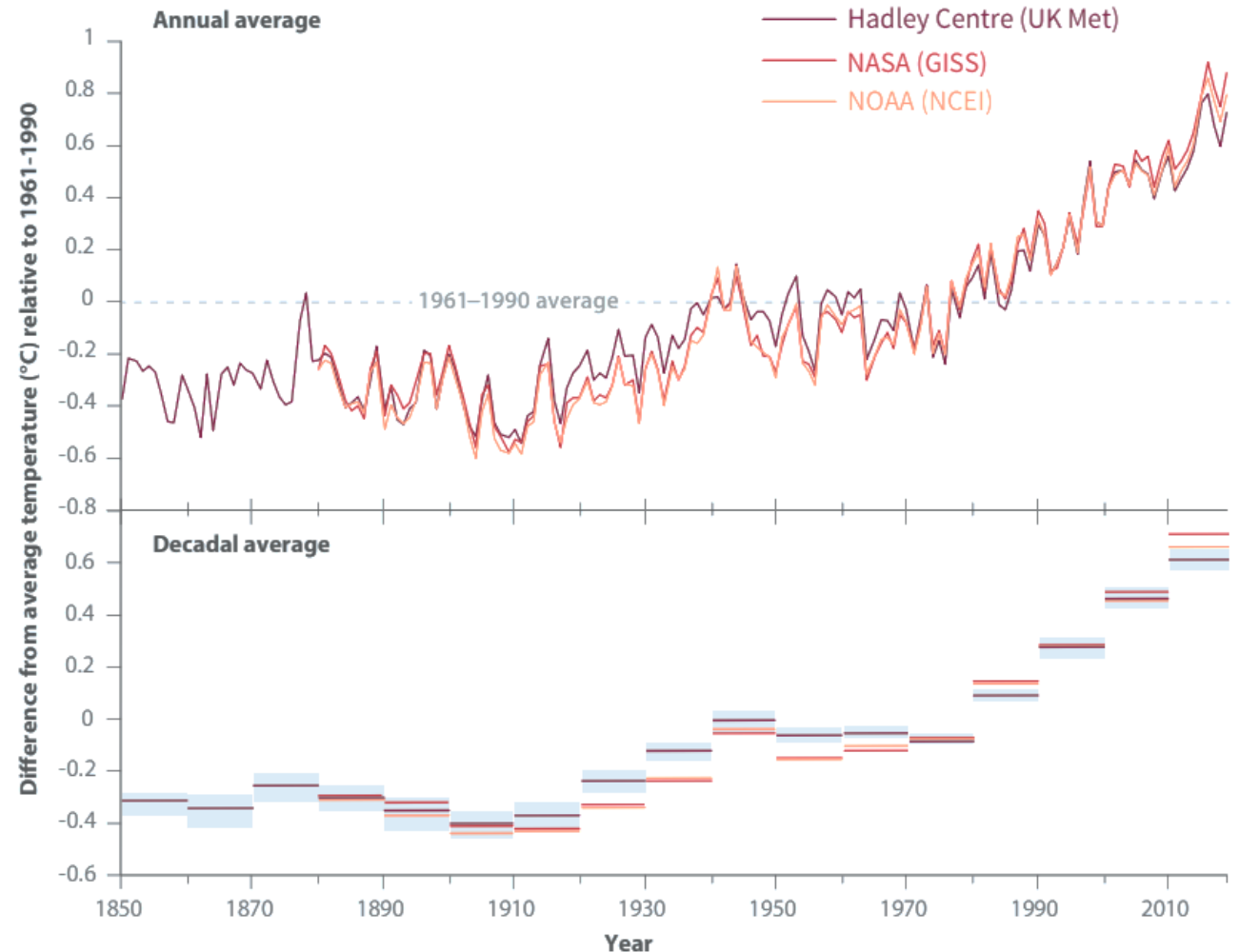
Ten Indicators of a Warming World



Evidence of Climate Change

Climate records show a warming trend.

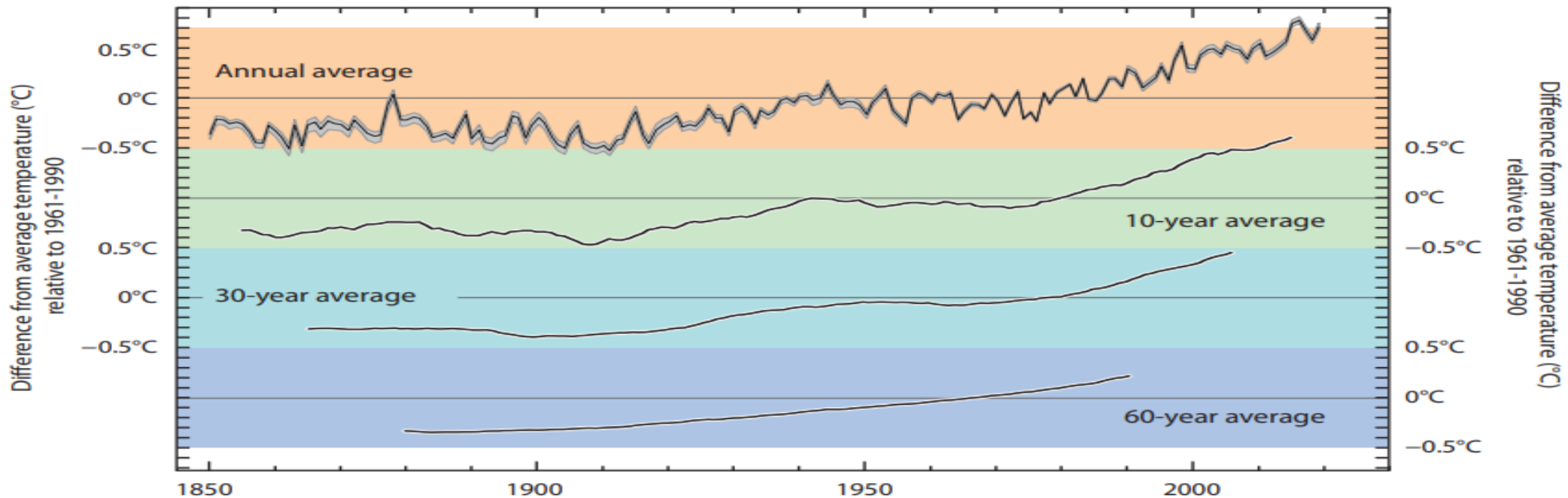
- *Earth's global average surface temperature has risen*, as shown in this plot of combined land and ocean measurements from 1850 to 2019 derived from three independent analyses of the available data sets.
- The temperature changes are relative to the global average surface temperature, averaged from 1961–1990.



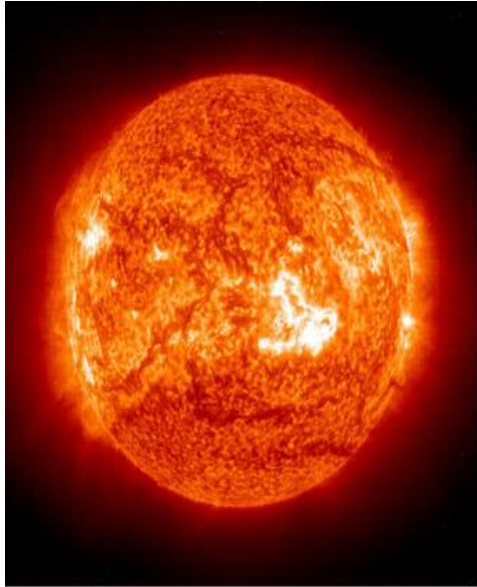
Evidence of Climate Change

Climate records show a warming trend.

The climate system varies naturally from year to year and from decade to decade. To make reliable inferences about human-induced climate change, multi-decadal and longer records are typically used. Calculating a “running average” over these longer timescales allows one to more easily see long-term trends. For the global average temperature for the period 1850-2019 (using the data from the UK Met Office Hadley Centre relative to the 1961-90 average) the plots show (top) the average and range of uncertainty for annually averaged data; (2nd plot) the annual average temperature for the ten years centred on any given date; (3rd plot) the equivalent picture for 30-year; and (4th plot) the 60-year averages.



Evidence of Climate Change



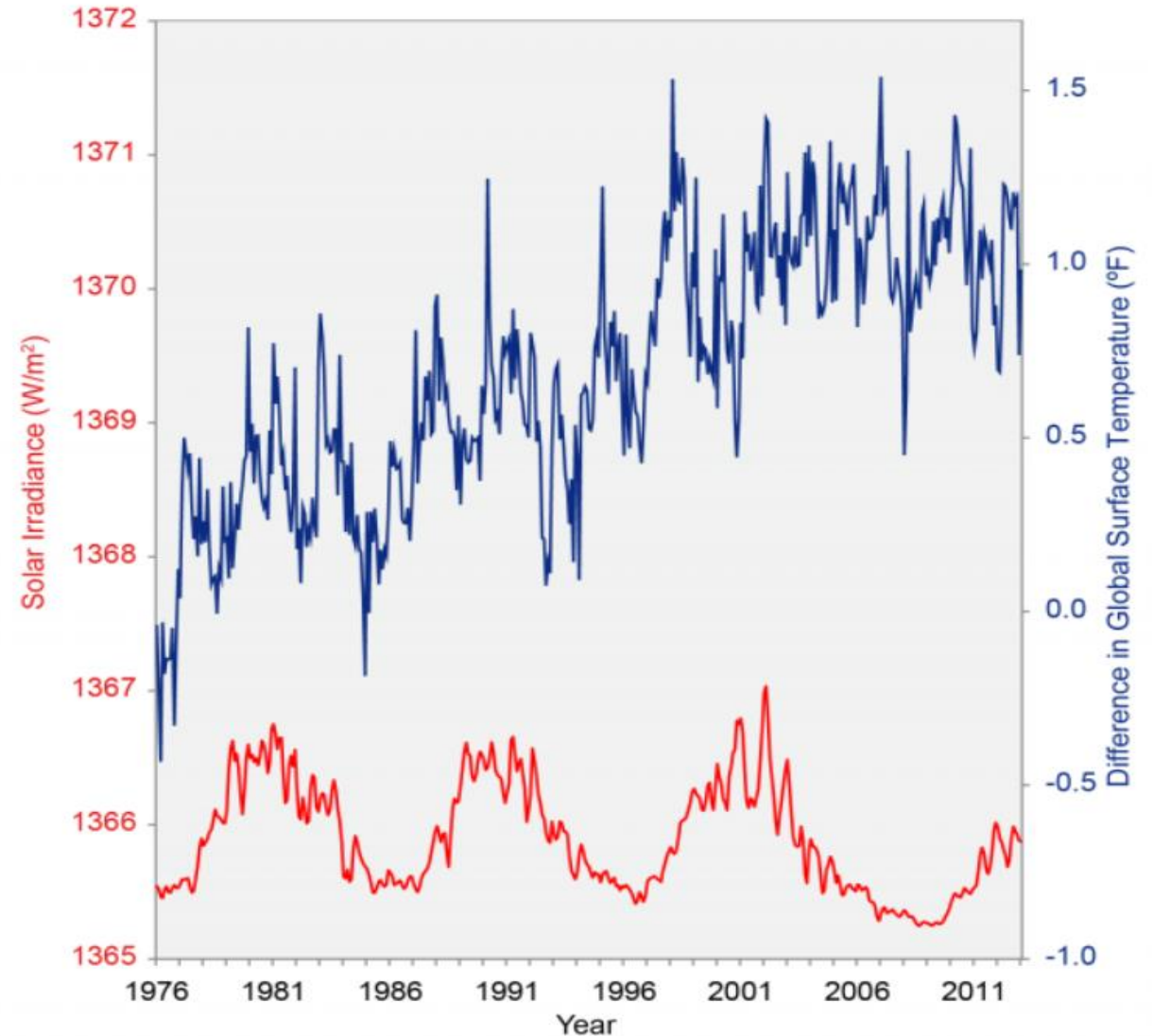
Solar Maximum (February 22, 2002)



Solar Minimum (May 10, 2008)

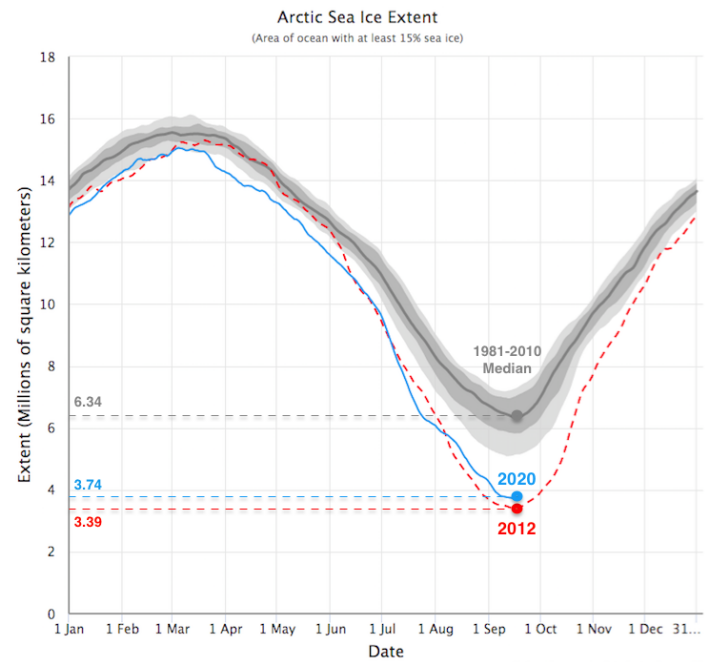
- *This warming is not caused by the increase in solar irradiance.*

Measurements of Surface Temperature and Sun's Energy



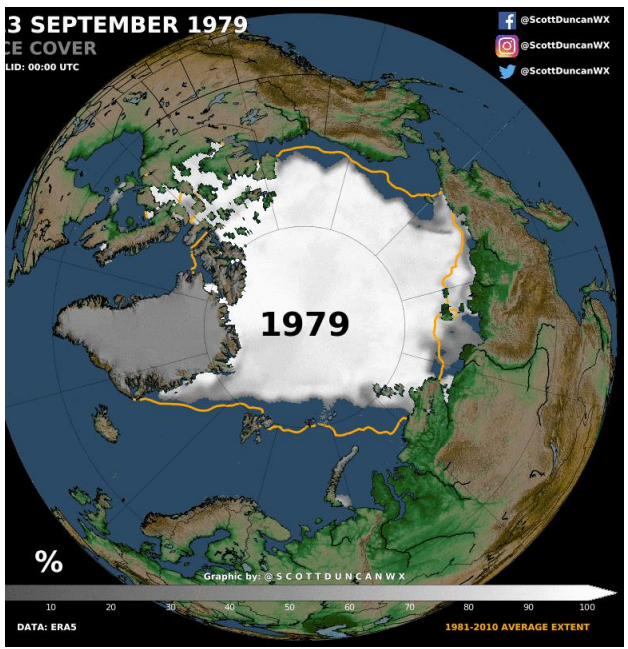
Evidence of Climate Change

Additional evidence of a warming trend can be found in the *dramatic decrease in the extent of Arctic sea ice at its summer minimum (which occurs in September), the decrease in June snow cover in the Northern Hemisphere.*

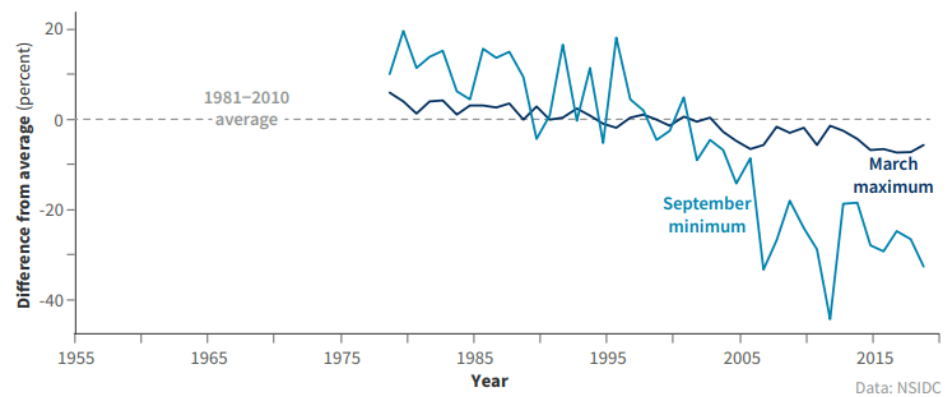


ChArctic v3.3.7 <https://nsidc.org/arcticseaicenews/chartic-interactive-sea-ice-graph/>

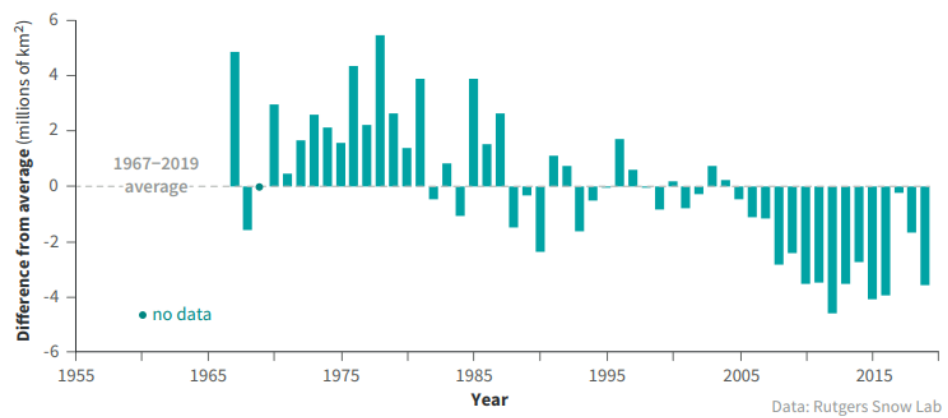
National Snow and Ice Data Center, Boulder, CO



Arctic sea ice extent in winter and summer (1979-2019)



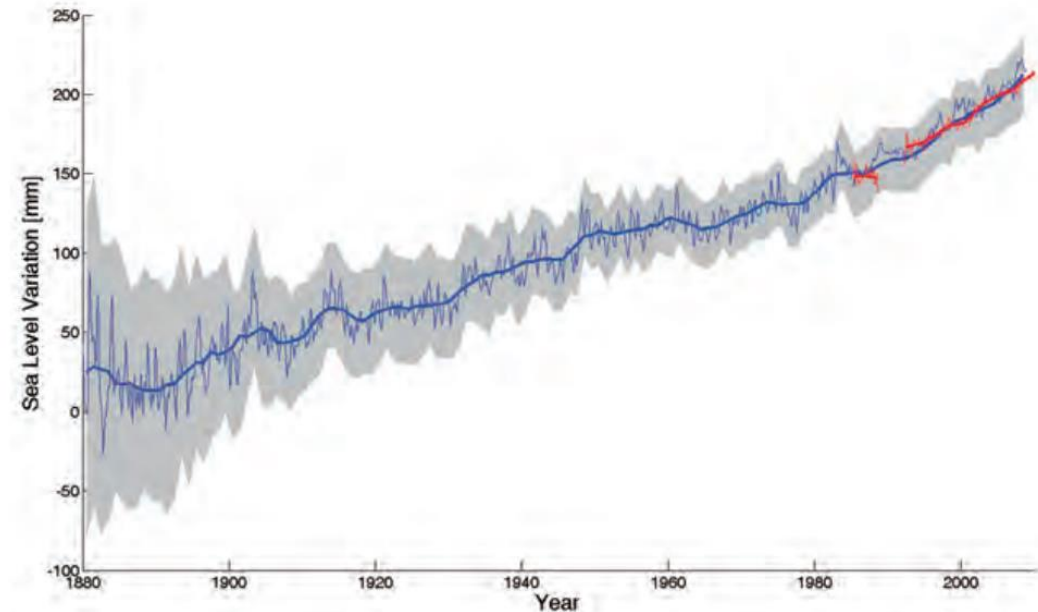
Northern Hemisphere June snow cover (1967-2019)



Evidence of Climate Change

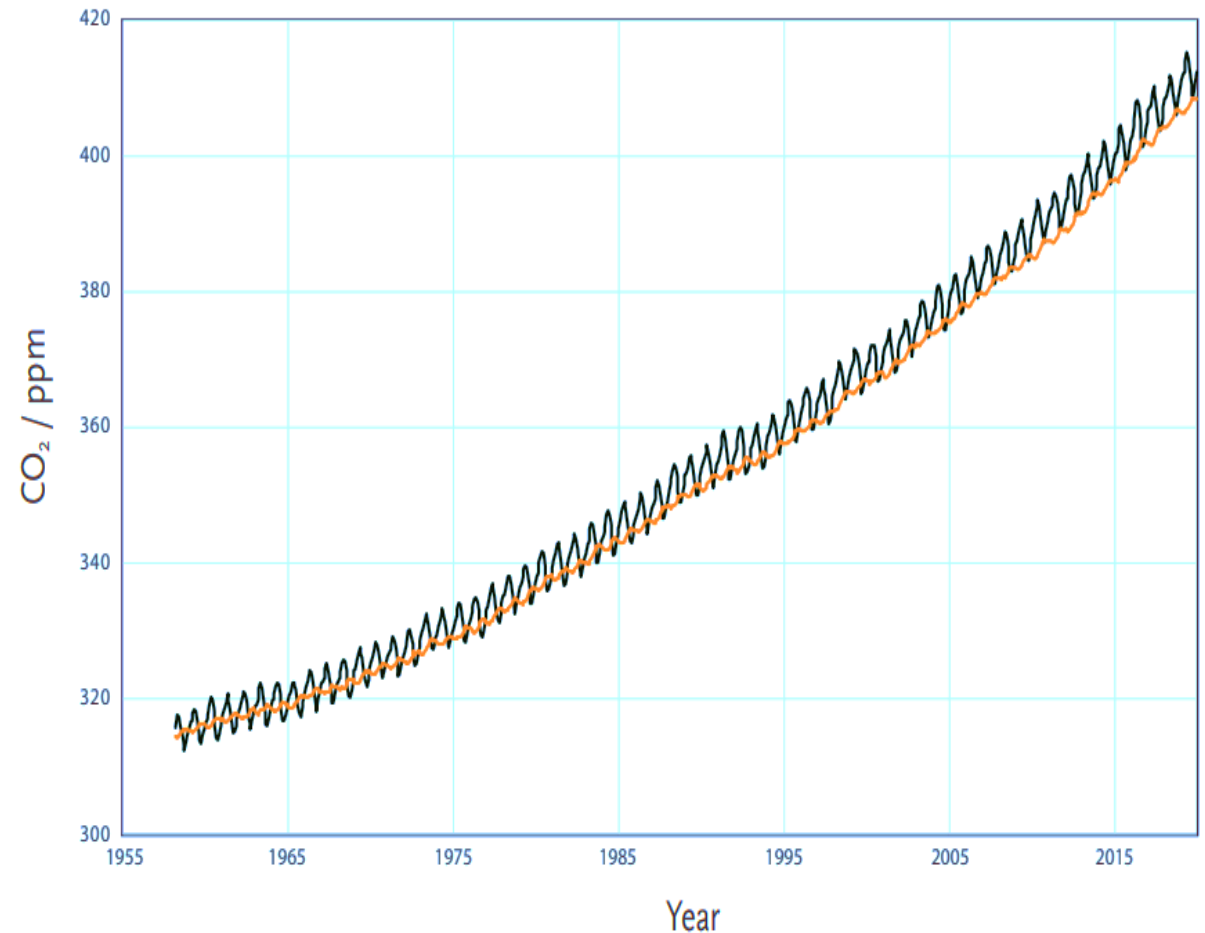
Observations show that the *global average sea level has risen by about 16 cm* since the late 19th century.

- Sea level is rising faster in recent decades; measurements from tide gauges (blue) and satellites (red) indicate that the best estimate for the average sea level rise over the last decade is centred on 3.6 mm per year.
- The shaded area represents the sea level uncertainty, which has decreased as the number of gauge sites used in calculating the global averages and the number of data points have increased



Evidence of Climate Change

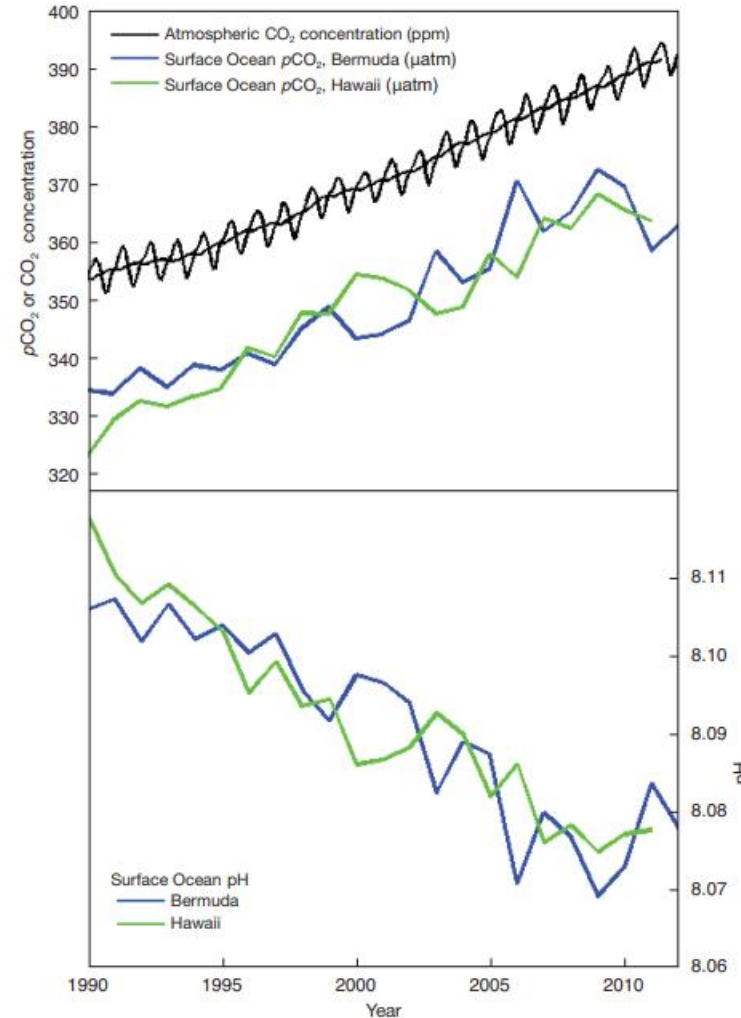
- Measurements of atmospheric **CO₂** since 1958 from the Mauna Loa Observatory in Hawaii (black) and from the South Pole (red) show a steady annual **increase in atmospheric CO₂ concentration.**
- The measurements are made at remote places like these because they are not greatly influenced by local processes, so therefore they are representative of the background atmosphere.
- The small up-and-down saw-tooth pattern reflects seasonal changes in the release and uptake of CO₂ by plants.



Evidence of Climate Change

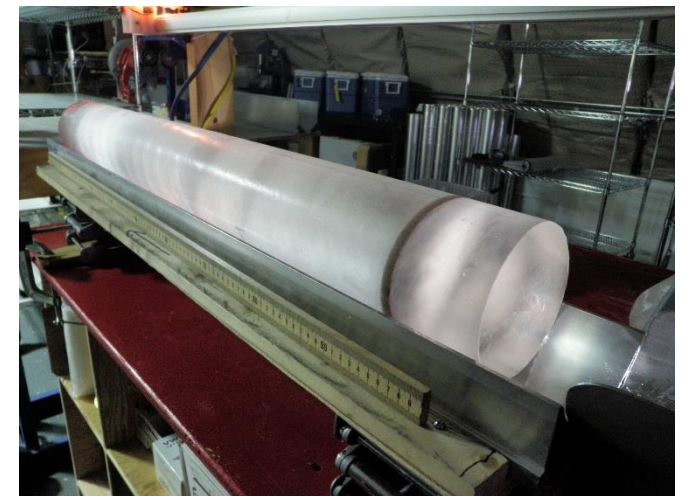
Ocean Acidification

As CO_2 in the air has increased, there has been an increase in the CO_2 content of the surface ocean (upper box), and a decrease in the seawater pH (lower box).

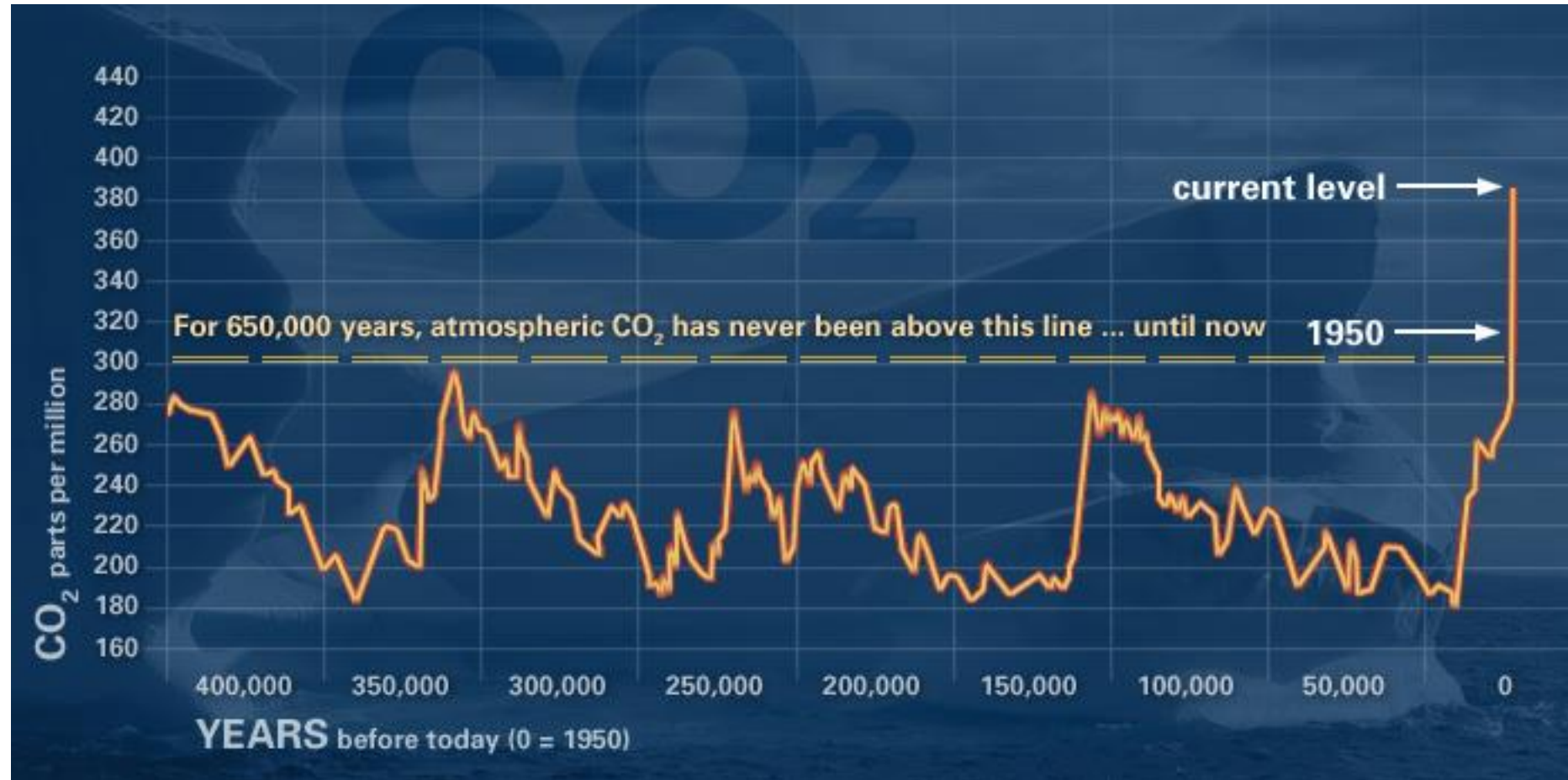


Evidence of Climate Change

Paleoclimatology *data from natural sources* like *ice cores*, *tree rings*, *corals*, *ocean* and *lake sediments* that have ***enabled scientists to extend the earth's climatic records back millions of years.***



Evidence of Climate Change



Consequences of climate change

Changes in

- Glaciers and ice sheets
- Sea level change
- Sea ice
- Heavy rainfall across the globe
- Extreme Drought
- Decline in Crop productivity
- Changes in ecosystems
- Hurricanes
- Rise in temperature
- Acidification of seawater



Thank You !

