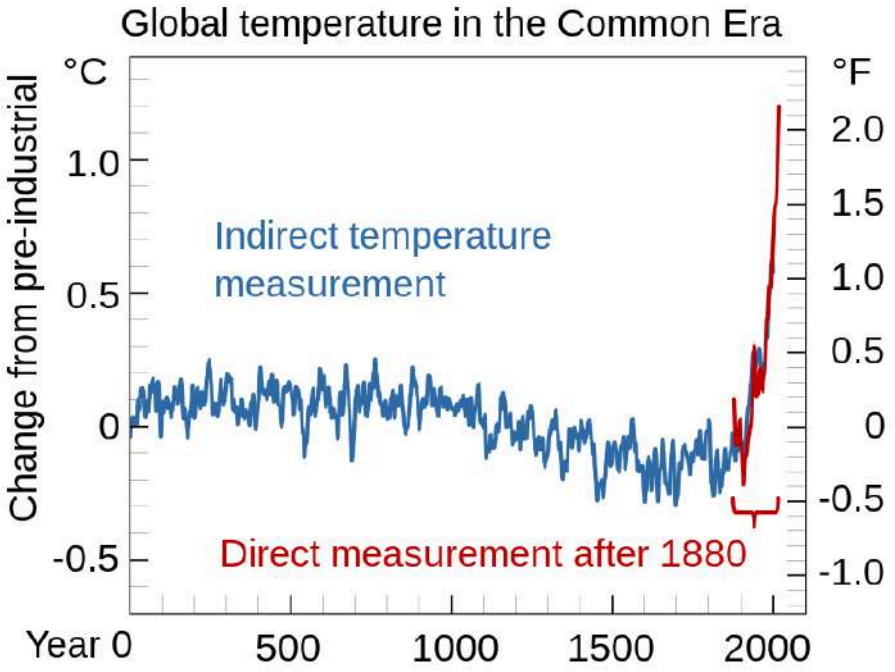
SEC-2 Evidences of climate change

Model Prepared by- Syfujjaman Tarafder, Gour Mahavidyalaya, Malda

Climate change refers to the long-term alterations in the average weather patterns that have been observed over many decades or longer. It is a phenomenon that affects the entire planet and has significant consequences for the natural world and human society. Climate change is caused by various factors, including human activities such as burning fossil fuels and deforestation, as well as natural factors such as volcanic activity and changes in solar radiation. In recent years, there has been a growing body of evidence that suggests that the Earth's climate is changing at an alarming rate. In this article, we will discuss the evidence of climate changes in the recent past.

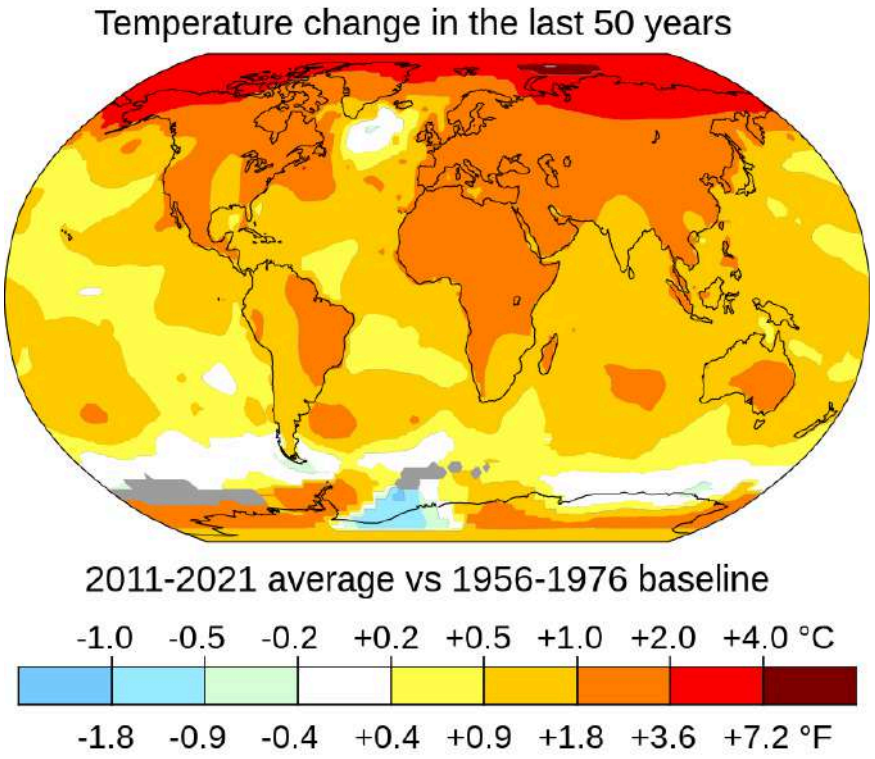
- ☐ **Temperature Rise:** One of the most prominent evidence of climate change is the increase in global temperatures. The Earth's temperature has risen by approximately 1 degree Celsius since the pre-industrial era. This may not seem like a significant increase, but it has far-reaching effects on the planet, including melting of glaciers and polar ice caps, sea level rise, and more frequent extreme weather events.



Here are some examples of how the rise in temperature is being observed around the world:

a. **<u>Rising surface temperatures:</u>** The average global surface temperature has increased by about 1.1°C since pre-industrial times, and each decade since the 1980s has been warmer than the previous one. This warming trend is observed in multiple regions of the world, including the Arctic, which is warming at more than twice the rate of the global average.

b. **Ocean warming:** More than 90% of the excess heat trapped in the Earth's atmosphere due to greenhouse gas emissions is absorbed by the oceans, causing the oceans to warm. This warming is affecting ocean ecosystems and contributing to rising sea levels, as water expands when it heats up. For example, the global average sea level has risen by about 20 cm since the beginning of the 20th century, and it is projected to rise by another 30-110 cm by the end of this century.



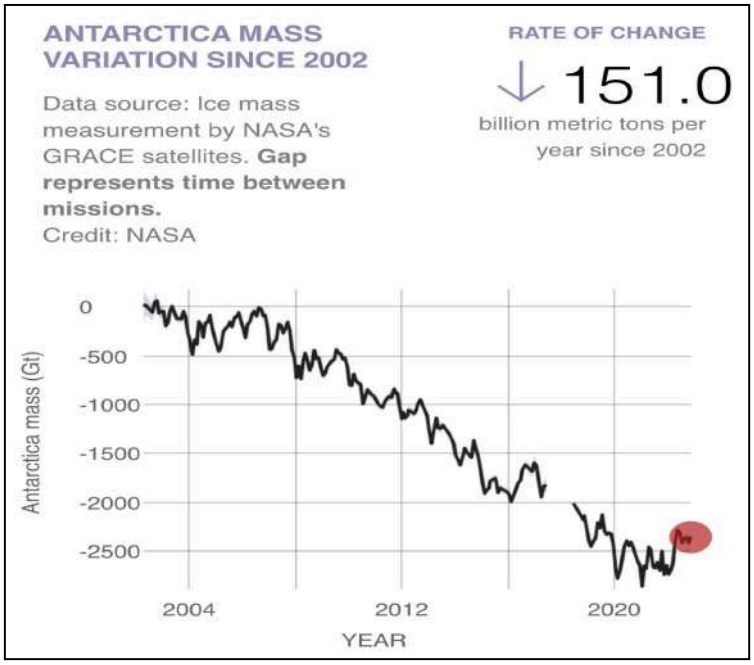
c. **Increased heatwaves and extreme weather events:** As temperatures rise, heatwaves and extreme weather events such as droughts, floods, and wildfires are becoming more frequent and severe. For instance, the recent heatwaves in Australia, Europe, and North America have broken temperature records and caused widespread impacts on human health and agriculture.

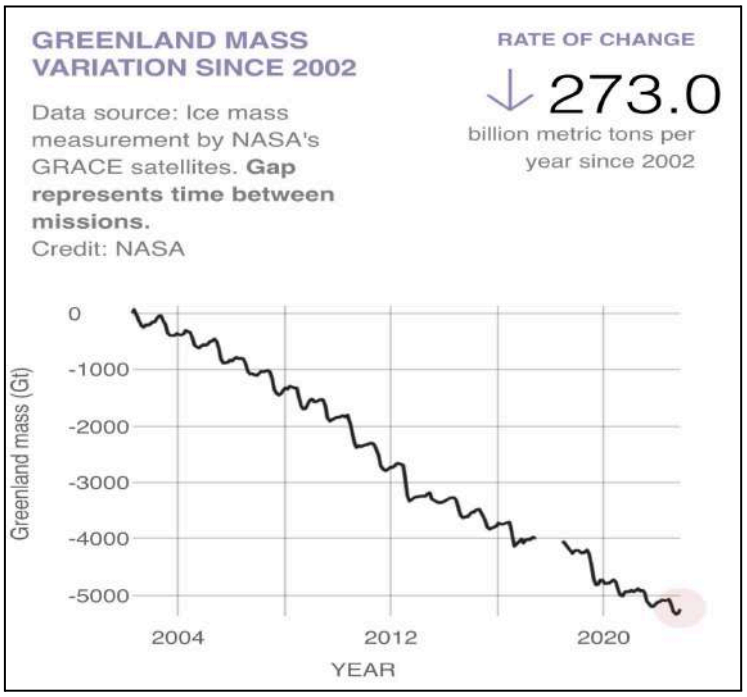
d. **Melting permafrost:** Permafrost is soil that has been frozen for at least two consecutive years and is found in areas of the Arctic and high-altitude regions. As temperatures rise, permafrost is thawing, releasing greenhouse gases such as methane and carbon dioxide, which further exacerbate global warming. The thawing of permafrost is also causing infrastructure damage and impacting Indigenous peoples' ways of life in the Arctic.

e. **Earlier spring and later autumn:** The arrival of spring is now occurring earlier, and the onset of autumn is delayed due to rising temperatures. This shift in seasons is affecting plant and animal behaviour, disrupting ecosystems, and impacting agricultural productivity. For

example, the timing of the cherry blossom season in Japan is now about a week earlier than it was a century ago.

- **Melting of ice:** Melting ice is one of the most compelling pieces of evidence of global climate change. Across the planet, glaciers, sea ice, and permafrost are melting at an alarming rate, with significant implications for the planet's ecosystems and human societies.





One of the most striking examples of melting ice is the Arctic sea ice, which has been shrinking at a rapid pace over the past few decades. In September 2021, the sea ice extent

reached its annual minimum, which was the 12th lowest on record. According to NASA, the Arctic sea ice has been declining at a rate of 12.8% per decade since the late 1970s.

The melting of Arctic sea ice has numerous implications for the planet, including rising sea levels, the loss of habitat for Arctic wildlife such as polar bears and walruses, and changes to ocean currents that could affect global weather patterns.

Glaciers around the world are also melting at a rapid pace. For example, in the *Himalayas, which are home to some of the world's largest glaciers, the ice is melting at a rate of about 0.3% per year.* This melting has significant implications for the region, including increased flooding and the loss of water resources for millions of people who depend on glaciers for their water supply.

Permafrost, which is frozen soil that covers much of the Arctic and sub-Arctic regions, is also melting at an alarming rate. As the permafrost melts, it releases large amounts of carbon dioxide and methane, two potent greenhouse gases, into the atmosphere, which could further accelerate climate change. Data from NASA's Gravity Recovery and Climate Experiment show *Greenland lost an average of 279 billion tons of ice per year between 1993 and 2019, while Antarctica lost about 148 billion tons of ice per year.*

- ☐ **Glacier retreat:** Retreating glaciers are a significant indicator of global climate change, as they are sensitive to changes in temperature and precipitation. *As temperatures rise, glaciers around the world are melting and retreating at an alarming rate*, and this phenomenon can be observed and measured, providing clear evidence of the effects of climate change.

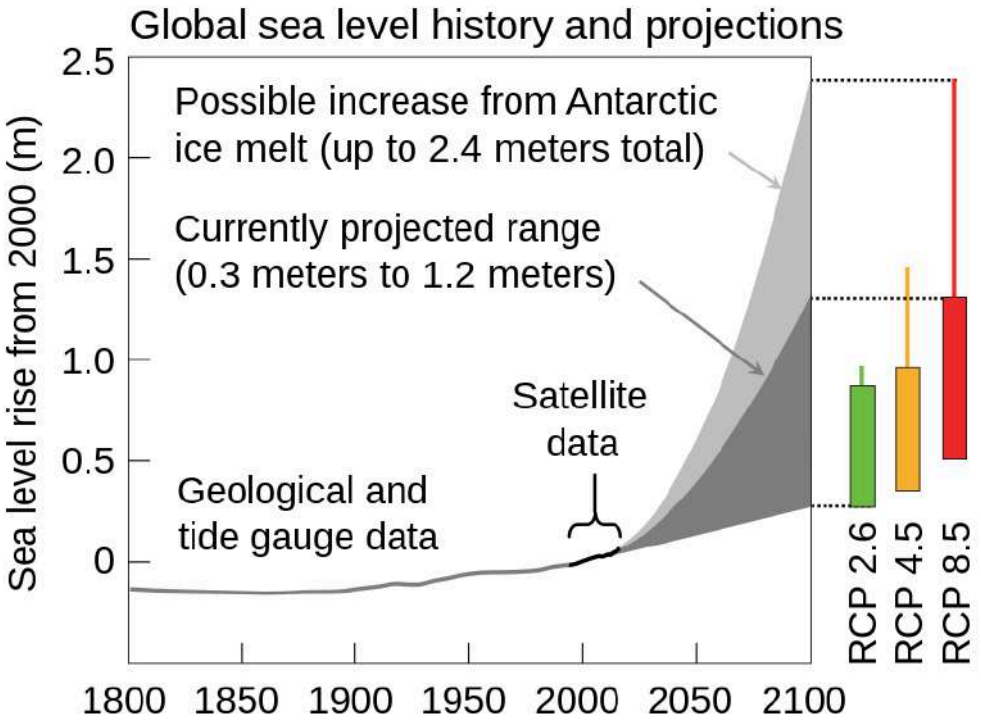
The retreat rates of glaciers can be measured using various techniques, including satellite imagery, aerial photographs, and ground-based surveys. These measurements show that glaciers are melting at a much faster rate than they are replenished by snow and ice, and the rates of melting are increasing. For instance, the *Columbia Glacier in Alaska has retreated over 20 km since the 1980s, while the Muir Glacier has retreated more than 10 km in the past century.*

The volume of ice in glaciers can also be measured using various techniques such as radar, sonar, and ground-based surveys. These measurements show that glaciers are losing significant amounts of ice each year, which is a direct result of rising temperatures and changes in precipitation patterns. For example, the *Greenland ice sheet is losing about 280 billion tons of ice per year, contributing to the rising sea levels.*

The size and length of glaciers can also be used to track changes over time. As glaciers retreat, they become smaller and shorter, providing clear evidence of the impact of climate change on the Earth's cryosphere. For instance, the *Athabasca Glacier in the Canadian Rockies has receded more than 1.5 km since the late 1800s, and the glaciers in the Himalayas have retreated by 21% over the last three decades*.

Glacier meltwater provides another key piece of evidence of climate change. As glaciers retreat, they release meltwater into rivers and streams, which can be analysed to determine changes in water quality and quantity. For example, studies show that meltwater from the Arctic is becoming increasingly acidic due to the absorption of carbon dioxide, and the meltwater from glaciers in the Andes is decreasing, impacting water supply for millions of people.

- ☐ **Sea Level Rise:** As the global temperature rises, the polar ice caps and glaciers are melting at an unprecedented rate. This has led to a rise in sea levels, which threatens to inundate low-lying areas and cause severe damage to coastal infrastructure. According to the *Intergovernmental Panel on Climate Change (IPCC), sea levels have risen by approximately 15 cm over the past century*.



Here are some examples of how sea level rise is being observed around the world:

a. **Global sea level rise**: The global average sea level has risen by about 20 cm since the beginning of the 20th century, and it is projected to rise by another 30-110 cm by the end of this century. This rise is a direct result of the melting of glaciers and ice sheets, as well as the thermal expansion of seawater due to warming temperatures.

b. **Coastal erosion and flooding**: Sea level rise is causing increased coastal erosion and flooding, especially during extreme weather events such as storms and hurricanes. This erosion and flooding can damage infrastructure and impact coastal communities' livelihoods. For example, some Pacific Island nations, such as Tuvalu and Kiribati, are already experiencing regular flooding due to sea level rise.

c. **Saltwater intrusion**: As sea levels rise, saltwater is intruding into coastal freshwater sources, such as aquifers and rivers, which can impact agriculture and drinking water supplies. This intrusion is also causing damage to coastal ecosystems, such as mangrove forests and wetlands, which provide important habitat for many species.

d. **Increased storm surges**: Rising sea levels are amplifying the impact of storm surges during extreme weather events, which can cause significant damage to coastal communities and infrastructure. For example, Hurricane Katrina's storm surge in 2005 caused extensive flooding in New Orleans and other coastal areas.

e. **Loss of coastal land:** As sea levels rise, coastal land is being lost to the sea, which can displace communities and wildlife. This loss is especially pronounced in low-lying areas, such as deltas and barrier islands, where land is more vulnerable to flooding and erosion.

- ☐ **Changes in Precipitation Patterns:** Climate change has also led to changes in precipitation patterns. Some areas are experiencing more frequent and intense rainfall, while others are experiencing longer and more severe droughts. These changes can have a significant impact on agriculture, water supply, and natural ecosystems.

Here are some examples of how these changes are being observed around the world:

a. **Increased frequency and intensity of extreme precipitation events**: As the atmosphere warms, it can hold more moisture, leading to more frequent and intense precipitation events. For example, the frequency of heavy precipitation events has increased in many parts of the world, including the United States and Europe.

b. **Changes in the timing and distribution of precipitation**: Climate change is causing changes in the timing and distribution of precipitation, which can have significant impacts on water resources, agriculture, and ecosystems. For instance, in many regions of the world, rainfall is becoming more erratic, with longer dry periods followed by heavier rainfall events.

c. **Changes in snowfall patterns:** Climate change is causing changes in snowfall patterns, particularly in mountainous regions. Snowmelt provides important water resources for many communities, but changes in snowfall patterns can lead to earlier snowmelt and reduced water availability later in the year.

c. Shifts in monsoon patterns: Monsoons are seasonal winds that bring heavy rainfall to many parts of the world, particularly in South Asia and Southeast Asia. Climate change is causing shifts in monsoon patterns, which can have significant impacts on agriculture and water resources in these regions.

Here are some examples of how these shifts are being observed:

i. Delayed onset and early withdrawal of monsoons: In recent years, the onset of monsoon rains in South Asia and Southeast Asia has been delayed, and the withdrawal of monsoons has been earlier than usual. This trend has been observed in countries such as India, Bangladesh, and Myanmar.

ii. Changes in the intensity and duration of monsoons: Climate change is causing changes in the intensity and duration of monsoon rains. In some regions, monsoons are becoming more intense, leading to increased flooding and landslides. In other regions, monsoons are becoming weaker, leading to reduced rainfall and droughts.

iii. Impact on agriculture: Monsoon rains are crucial for agriculture in South Asia and Southeast Asia, providing water for crops and supporting livelihoods. Changes in monsoon patterns can have significant impacts on agricultural productivity, food security, and rural livelihoods. For example, droughts caused by weak monsoons in India have led to crop failures and increased farmer distress.

iv. Impact on water resources: Monsoon rains are also an important source of freshwater for many communities in South Asia and Southeast Asia. Changes in monsoon patterns can impact water availability, leading to water stress and conflicts over water resources. For example, reduced monsoon rainfall in Vietnam has led to saltwater intrusion into freshwater sources, impacting agricultural production and livelihoods.

v. Impact on ecosystems: Monsoons play an important role in supporting ecosystems in South Asia and Southeast Asia, providing water for rivers, wetlands, and forests. Changes in monsoon patterns can have significant impacts on these ecosystems, leading to changes in biodiversity and ecosystem services. For example, changes in monsoon patterns have led to reduced water availability for the Sundarbans mangrove forest, which is a critical habitat for many species.

d. **Changes in the frequency and intensity of droughts:** Climate change is causing changes in the frequency and intensity of droughts in many parts of the world. For example, in some regions of Africa, droughts are becoming more frequent and severe, leading to food insecurity and other humanitarian crises.

- ☐ **Ocean Acidification:** Another significant consequence of climate change is the acidification of the oceans. As carbon dioxide from the atmosphere dissolves in the ocean, it reacts with seawater to form carbonic acid, which lowers the pH of the water. This makes it more difficult for marine organisms such as coral reefs and shellfish to form their shells, which can have a devastating impact on the entire marine ecosystem. Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30%. This increase is due to humans emitting more carbon dioxide into the atmosphere and hence more being absorbed into the ocean. The ocean has absorbed between 20% and 30% of total anthropogenic carbon dioxide emissions in recent decades (7.2 to 10.8 billion metric tons per year).