Global temperature changes

Global temperature change: Highlights

- The relentless global heat continued as average surface temperature on Earth in July 2020 was the second warmest on record

- In 2019, the average temperature across global land and ocean surfaces was 0.95°C above the twentieth-century average of 13.9°C, making it the second-warmest year on record.

  - The global annual temperature has increased at an average rate of 0.07°C per decade since 1880 and over twice that rate (+0.18°C) since 1981.

- The five warmest years in the 1880–2019 record have all occurred since 2015, while nine of the 10 warmest years have occurred since 2005.

- From 1900 to 1980 a new temperature record was set on average every 13.5 years. Since 1981, it has increased to every 3 years.

Conditions in 2019

According to the 2019 Global Climate Report from National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information, 2019 began with a weak-to-moderate El Niño event in the tropical Pacific Ocean. Temperatures were warmer than average across most global land and ocean areas during most of the year.

Effects of global warming

- **Ocean Warming**
  - Thermal expansion
  - Coastal erosion
  - Arctic erosion
  - Warmer bottom water
  - Coral die off
- **Ice loss**
  - Melting glaciers and permafrost
  - Melting ice sheets
- **Climate change**
  - Extreme temperatures
  - Drought
  - Wind events like cyclones, tornados etc.
  - Severe rainfall
- **Sea level rise**
  - Due to thermal expansion, ice loss, melting of glaciers etc.

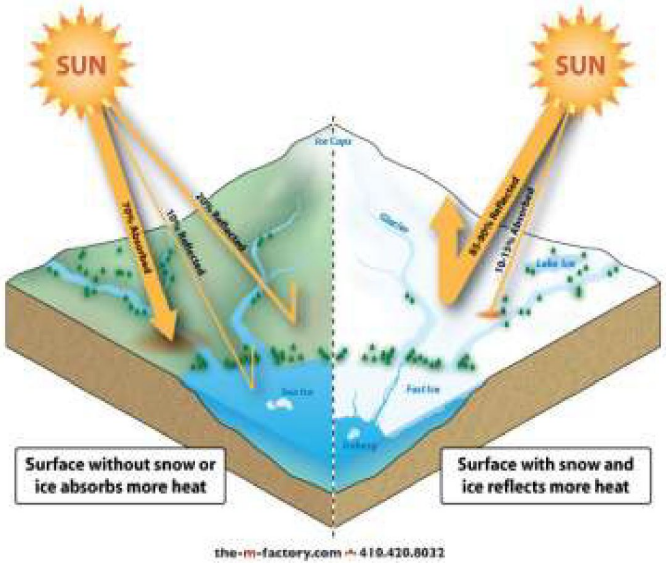
Ice melting :Global overview

Sources of melting ice

- Greenland ice sheets: 286 gt/y
- Antarctic ice sheets: 127 gt/y
- Glaciers (excluding Greenland and Antarctica ice sheets): 335 gt/y

Albedo

- A measure of how much of the Sun's energy is reflected off an object back out to space compared to how much is trapped in Earth's atmosphere.
- Snow, ice and clouds have a relatively high Albedo so generally reflect more of the Sun's energy back to space which has a cooling effect on the Earth.
- Cirrus clouds have a lower Albedo transmitting more radiation through to Earth's surface and trapping Earth's reflected radiation. This increases the temperature on Earth.
- Changes in the polar regions can cause more warming in the entire planet earth system through feedback effects. One such effect is the reduction of ice and snow due to warmer temperatures.
    - When the snow and ice disappears, less sun rays are reflected out and instead the heat is absorbed by land and sea - which causes further increase in the warming.
- Change to the Earth's Albedo is a powerful driver of climate.
- When the planet's Albedo or reflectivity increases, more incoming sunlight is reflected back into space. This has a cooling effect on global temperatures. Conversely, a drop in Albedo warms the planet.



Measuring Albedo

Albedo is measured in scale from 0.0-1.0

- 1.0 being the most reflective.
  - For example an Albedo of 1.0 would be reflecting back 100% of light.
- Albedo of fresh snow is about 0.9
- 0.0 being the most absorbing surface.
  - For example and Albedo of 0.0 would be absorbing 100% of light.

Terrestrial effects

Trees: Because trees tend to have a low Albedo, removing forests would tend to increase Albedo and thereby could produce localized climate cooling. In seasonally snow-covered zones, winter Albedo of treeless areas are 10% to 50% higher than nearby forested areas because snow does not cover the trees as readily .

Snow: Snow Albedo can be as high as 0.9; this, however, is for the ideal example: fresh deep snow over a featureless landscape. If a snow covered area warms, snow tends to melt, lowering the Albedo, and leading to more snowmelt.

Water: Water reflects light very differently from typical terrestrial materials. At the scale of the wavelength of light even wavy water is always smooth so the light is reflected in a locally specular manner. Although the reflectivity of water is very low at low and medium angles of incident light, it increases tremendously at high angles of incident light such as occur on the illuminated side of the Earth near the terminator. However, waviness causes an appreciable reduction. Since the light specularly reflected from water does not usually reach the viewer, water is usually considered to have a very low Albedo in spite of its high reflectivity at high angles of incident light.

Clouds: Cloud Albedo is an important factor in the global warming effect. Different types of clouds exhibit different reflectivity. Albedo and climate in some areas are affected by artificial clouds, such as those created by the contrails of heavy commercial airliner.

Impacts

- Much of the sunlight reflects back when it reaches the earth surface, if it’s not reflected then its absorbed, and that’s why the temperature increases
- This melts the ice and increases the global temperature to a few degrees, when ice melts, it can cause flooding in some areas.
- Exposed water or exposed land is darker in colour and it absorbs more energy from the sun. When the ice melts, more land is exposed, this absorbs more heat, melting more ice.
- The snow and ice play a important role. Without them the sunlight will not reflect back and temperature will rise causing global warming due to an imbalance of light being reflected and absorbed.

Irreversible changes

- Human influence on the climate system is confirmed.
- Recent anthropogenic emissions of Green house gases are the highest in history.
- Recent climate changes have had widespread impacts on the ecosystems.

Observations

- Atmosphere and ocean have warmed
- Snow and ice amounts have reduced
- Sea level has risen
- Ocean pH has decreased by 0.1

Risk and impacts

- Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system.
- It will increase the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.
- All emission scenarios project increase in surface temperature causing more and longer lasting heat waves
- Extreme precipitation events will become more intense and frequent in many regions
- The ocean will continue to warm and acidify
- Global mean sea level to rise.

Sea level rise and its impact

- Sea-level rise due to global warming occurs primarily because **water expands as it warms up**.
- The melting ice caps and mountain glaciers also add water to the oceans, thus rising the sea level.

- The contribution from large ice masses in Greenland and Antarctica is expected to be small over the coming decades. But it may become larger in future centuries.

- Sea-level rise can be offset up by irrigation, the storage of water in reservoirs, and other land management practices that reduce run-off of water into the oceans.
- Changes in land-levels due to coastal subsidence or geological movements can also affect local sea-levels.

Sea level rise: Highlights

- Sea level has risen 8–9 inches (21–24 centimetres) since 1880.
- In 2019, global sea level was 3.4 inches (87.61 mm) above the 1993 average—the highest annual average in the satellite record (1993-present). This is an increase of 0.24 inches (6.1 mm) from 2018.
- The rate of sea level rise is accelerating: it has more than doubled from 0.06 inches (1.4 millimetres) per year throughout most of the twentieth century to 0.14 inches (3.6 millimetres) per year from 2006–2015.
- In many locations along the U.S. coastline, high-tide flooding is now 300% to more than 900% more frequent than it was 50 years ago.
- Even if the world follows a low greenhouse gas pathway, global sea level will likely rise at least 12 inches (0.3 meters) above 2000 levels by 2100.
- If we follow a pathway with high emissions, a worst-case scenario of as much as 8.2 feet (2.5 meters) above 2000 levels by 2100 cannot be ruled out.