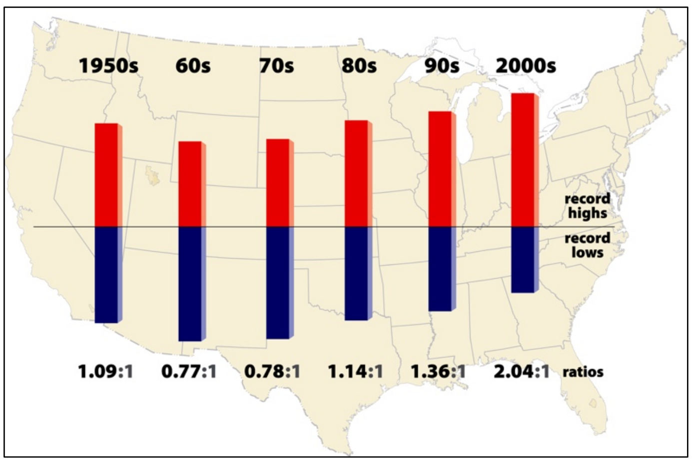
The Greenhouse Effect

- A lab demo of the heat-trapping properties of CO_2 (2:19) https://www.youtube.com/watch?v=Ge0jhYDcazY

Heat energy that has been reflected by Earth's surface is absorbed by gases in the atmosphere. This is known as the greenhouse effect. The greenhouse gases that absorb heat energy include water (H_2O), carbon dioxide (CO_2), methane, and a number of other less important ones. Together greenhouse gases make up less than 1% of the atmosphere. Without these gases, Earth's average temperature would be around -18˚C, the same as on the moon. When they stay at stable levels in our atmosphere, the global climate stays stable. When their levels drop enough, we get an ice age. For the past hundred years, human activity has been increasing greenhouse gas levels. As a result, the planet is warming.



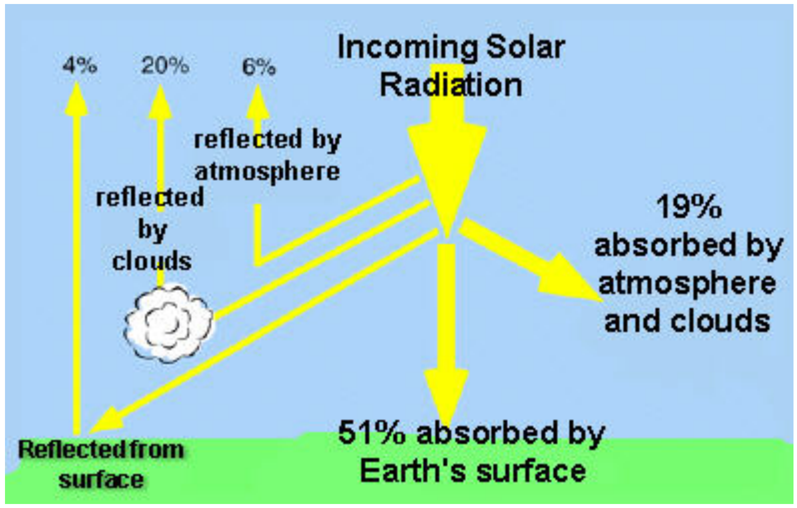
The ratio of record highs to record lows in the US each decade since the 1950s. What do these changes tell us?

The average global temperature has already risen by an average of 1.5˚F. That might seem like a small change, but it is actually a significant increase. In the past, a one- to two-degree drop was all it took to plunge the Earth into the Little Ice Age. A five-degree drop was enough to bury a large part of North America under a towering mass of ice 20,000 years ago.

Sunlight, or solar radiation, is one portion of the radiation given off by the sun. It mostly consists of infrared and visible light, and a small amount of ultraviolet light. When solar radiation reaches Earth's atmosphere, oceans and land, some of it is absorbed, and warms the surfaces it strikes. Some of it is re-radiated back into the air as infrared radiation (IR). You have probably seen a heat lamp warming food in a cafeteria. The heat lamp is using IR to heat the food.

Greenhouse gases don't block light, but they do absorb IR. They also re-emit it. When IR hits a greenhouse gas molecule, the molecule absorbs the energy. It becomes excited, vibrates, then re-emits or releases the energy in all directions. The higher the concentration of greenhouse gases, the higher the chances are that the heat energy released by one molecule will hit and be absorbed by another. This results in heat being trapped in the atmosphere. Eventually the heat energy escapes to space. However, not enough escapes to balance the amount that is being trapped by excess greenhouse gases.

Scientists have mapped Earth's "energy budget" to account for the greenhouse effect. Earth's land and ocean surfaces receive *almost twice as much energy from the greenhouse effect than they do directly from the Sun!*



Earth's energy inputs and outputs.
Image Source: solpass.org

In systems terms. Think of the atmosphere as a bathtub. The flow of energy from the faucet into the tub (solar radiation) has not changed. However, the water level in the tub is rising (because heat contained in the atmosphere is increasing. You can think of the bathtub "drain" being clogged by greenhouse gases. This means that the draining of heat from the bathtub through the drain (heat escaping back into space) cannot keep up with the rate of inflow from the faucet of the sun.

More information

To learn more about the **Greenhouse Effect**, check out these resources:

- Iain Stewart demonstrates how CO_2 can absorb and block heat using an IR camera and a candle (1:08)
  https://www.youtube.com/watch?v=Ot5n9m4whaw

- This interactive simulation uses a molecular model to show the impact of greenhouse gas concentration on temperature. It shows "sunlight photons" and "infrared photons" as the sources of solar energy in the system. A final interactive shows how different greenhouse gases react when hit by both types of photons (~10:00)
  https://phet.colorado.edu/en/simulation/legacy/greenhouse