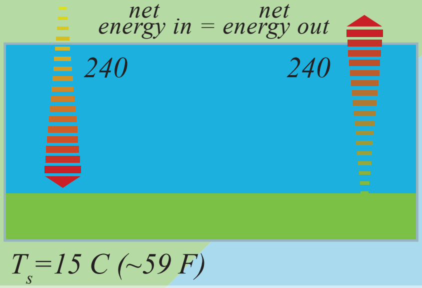
CO_2 *Forcing and Response*

Over long time scales, the Earth is in equilibrium with its space environment.

1: Starting Point



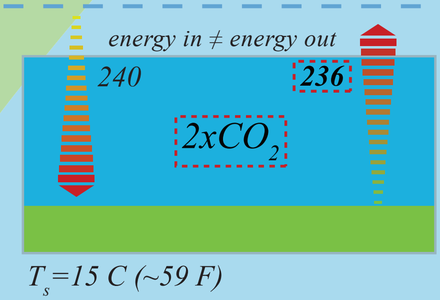
Earth at equilibrium with net energy input from the Sun.

(340 W/m^2 * (1 - albedo)) = 240 W/m^2

Average surface temperature 15 C (~59 F)

Earth's temperature has averaged 15 C (~59 F), with a balance of 240W/m^2 of energy being absorbed from the Sun; and 240 W/m^2 being emitted to space as heat energy.

2: The Experiment

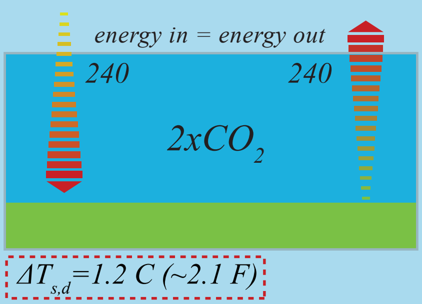


Instantaneously double CO_2 in concentration in atmosphere

Average energy emitted by Earth drops 4 W/m^2 (236 vs 240) because of additional energy absorption by CO_2

Using well understood physics, we can explore what happens if the concentration of carbon dioxide (CO_2) in the atmosphere doubles. Since CO_2 retains heat, the immediate effect is a small reduction in the amount of heat emitted to space – an imbalance.

3: Response

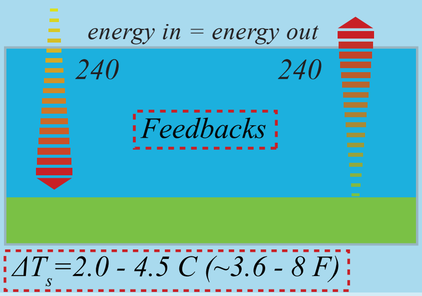


All other things being equal, simple physics theory says:
Average surface temperature rises 1.2 C (~2.1F)

Energy back in balance

To return to equilibrium, Earth's average surface temperature would increase by 1.2 C to 16.2 C (61.2 F) in order to emit more heat and return to balance with the Sun.

4: Feedbacks



In the Earth system, other processes kick in (water vapor feedback, cloud feedback, ice-albedo feedback, etc).

Net effect: Average surface temperature estimated to rise 2 - 4.5 C (~3.6 - 8 F)

However, the Earth is not quite that simple: rising temperatures have other effects, like increasing water vapor (a greenhouse gas) in the atmosphere, melting ice sheets (which reflect sunlight) and changing cloudiness. While not entirely understood, these feedbacks amplify the temperature rise to return to equilibrium. Scientists estimate the Earth's average temperature would actually rise between 2 and 4.5 C (3.5 and 8 F) before equilibrium was restored.

**Indicates a change has occurred*