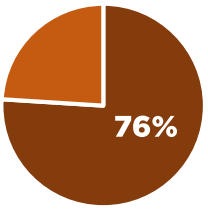
Science Background: Carbon Cycle and Storage

CO_2 Share of Global GHG emissions (2017)

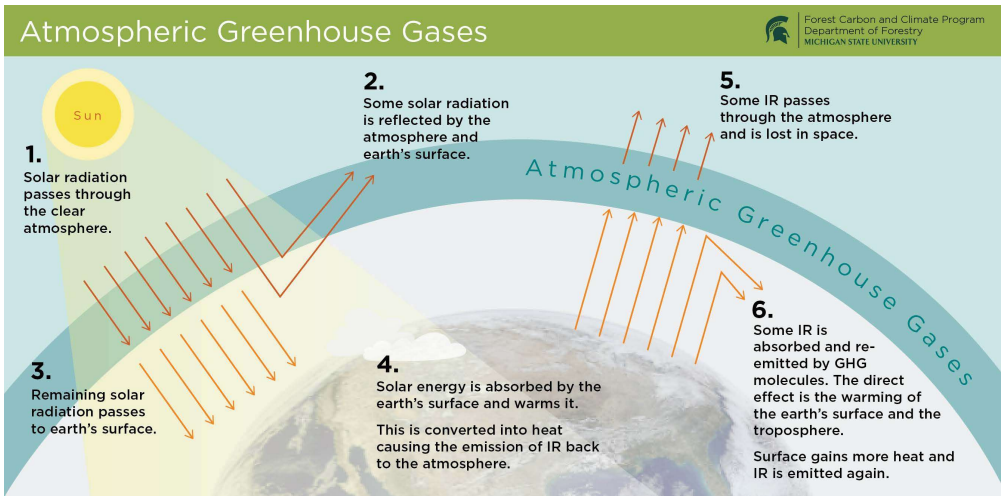


Why Carbon?

- CO_2 is a highly consequential human-made greenhouse gas and closely linked to climate change
- In 2017, CO_2 accounted for ~76% of total global GHG emissions
    - Fossil fuel use
    - Deforestation
- Forests present a uniquely effective opportunity to sequester and store carbon through natural processes of photosynthesis and forest ecosystem cycling

Greenhouse Effect

- **Greenhouse Effect**: warming that results when the atmosphere traps heat radiating from Earth towards space
- Under stable conditions, energy entering and exiting Earth's system will be balanced and the Earth will maintain a constant average temperature
- Current measurements indicate the Earth absorbs 0.85 watts/m^2 over reflections back to space due to an an excess of anthropogenic greenhouse gas concentration



Data source: Okanangan University College in Canada, US EPA, UNEP
Image Adapted by MSU FCCP

Global Warming Potential (GWP)

- **GWP:** the amount of heat a particular greenhouse gas can trap in the atmosphere
- Calculated from three factors:
    1. Absorption of infrared radiation by the gas

Gas Compound	20-year GWP	100-year GWP
Carbon Dioxide (CO_2)	1	1
Methane (CH_4)	84	28
Nitrous Oxide (N_2O)	264	265
HFC-134a	3710	1300
CFC-11	6900	4660
Carbon tetrafluoride (CF_4)	4880	6630

2. Wavelengths of its absorption peaks
3. Residence time of gas in the atmosphere

- Calculated in reference to CO_2
  - GWP of CO_2 is 1
  - Example: CH_4 has a GWP of 28 over a 100-year period, meaning 1 ton of CH_4 released into the atmosphere will trap as much heat as 28 tons of CO_2 over 100 years.

Comparing GHGs – CO_2e

- **CO_2e:** carbon dioxide equivalent, the amount of CO_2 equivalent to the same global warming impact of a specific greenhouse gas
- CO_2e = GHG x GWP
  - Example: CH_4 is 28x the GWP of CO_2, so 1kg CH_4 = 25 kg CO_2e

Recent Trends in Atmospheric CO_2 Concentrations

- Keeling Curve, Mauna Loa Observatory
  - Red curve = CO_2 data measured
  - Black curve = seasonally corrected data
- Increase in yearly average of CO_2 concentrations over past 60 years

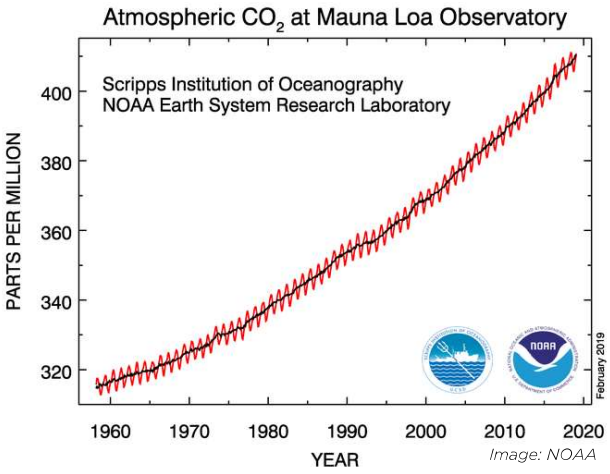


Image: NOAA

Long-term Trends in Atmospheric CO_2 Concentrations

- Long-term variability of CO_2 in atmosphere
- 400,000 to 100 years ago, CO_2 concentration never exceeded 300ppm
- Today, CO_2 concentration exceeds 400ppm and continues to increase annually

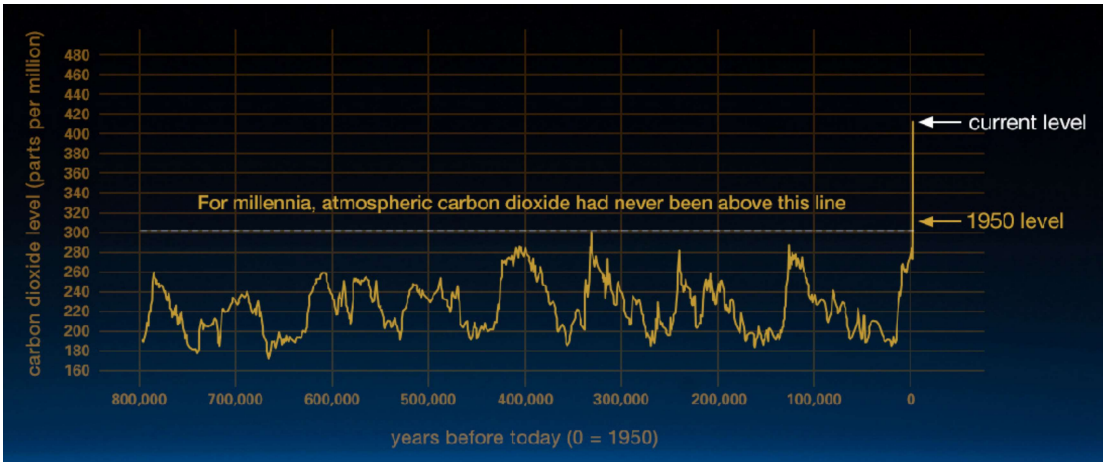


Image: NASA