OUR CHANGING ATMOSPHERE

A GRAPHING ACTIVITY USING ATMOSPHERIC CARBON DIOXIDE DATA FROM NOAA, THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

MAUNA LOA CO_2 DATA

- THE DATA YOU ARE GOING TO GRAPH ARE MEAN MONTHLY ATMOSPHERIC CO_2 DATA FROM MAUNA LOA, COLLECTED BY THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA).
- USE THE GLOBE TO LOCATE MAUNA LOA. IS IT IN THE NORTHERN OR SOUTHERN HEMISPHERE?


Mauna
Loa

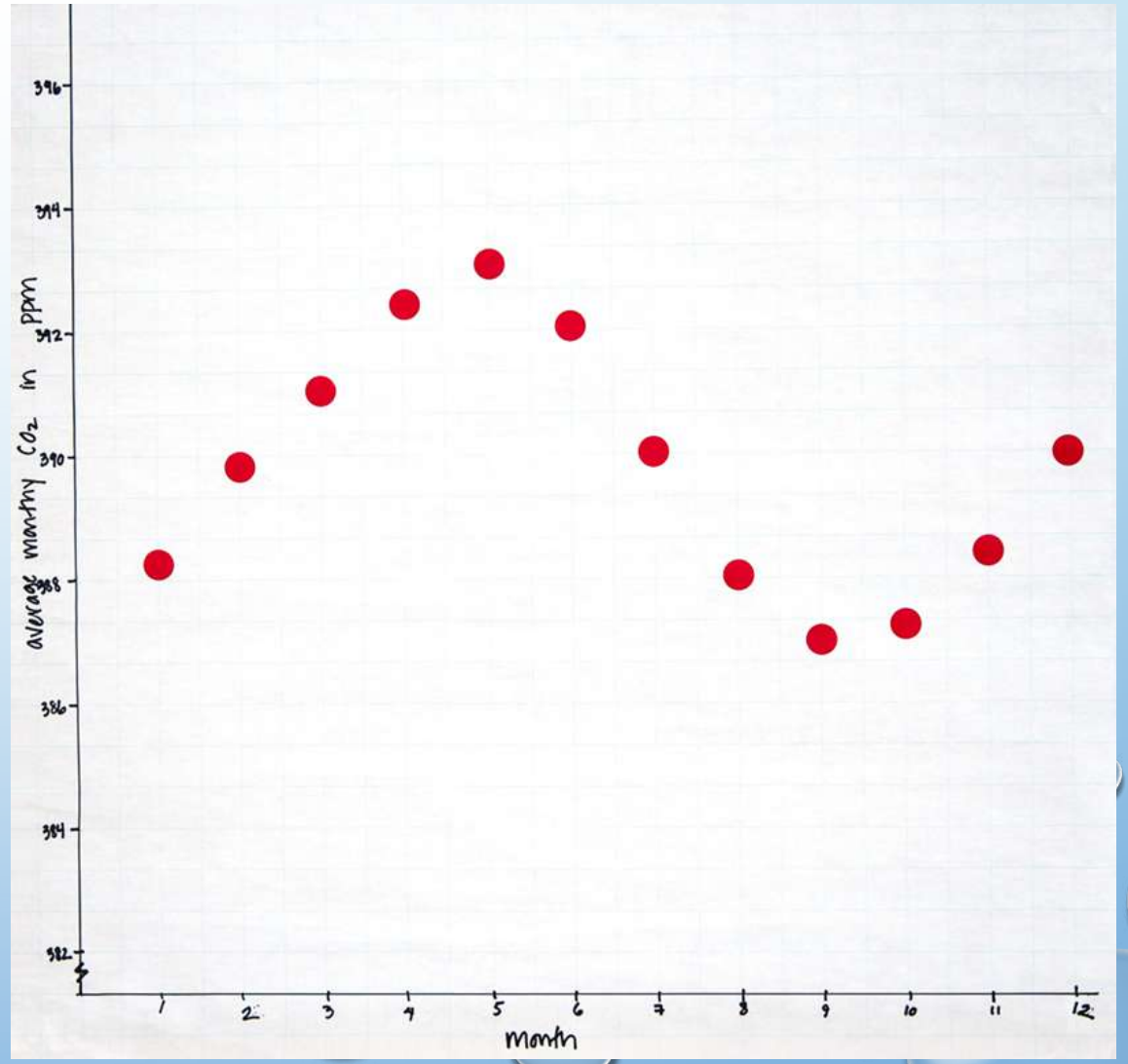

Greenland
CANADA
UNITED STATES
RUSSIA
KAZAKHSTAN
MONGOLIA
CHINA
INDIA
ALGERIA
LIBYA
EGYPT
MALI
NIGER
CHAD
SUDAN
BRAZIL
INDONESIA
AUSTRALIA
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
SOUTH PACIFIC OCEAN
SOUTHERN OCEAN
Antarctica

GRAPHING

- MATERIALS:
  - LABELED GRAPH PAPER
  - BLUE TAPE
  - ENVELOPE
    - DOT/STAR STICKERS (12) - NORTH
    - DOT/STAR STICKERS (12) - SOUTH
    - MAUNA LOA - CO_2 DATA (PINK SLIP)
    - SOUTH POLE - CO_2 DATA (GOLD SLIP)
- WRITE THE MAUNA LOA CO_2 VALUES FROM YOUR DATA SHEET ON THE STICKY DOTS, ONE MONTHLY VALUE PER DOT.
- PLACE THE DOTS APPROPRIATELY ON THE GRAPH
- LABEL THE GRAPH WITH THE YEAR IN WHICH YOUR DATA WERE COLLECTED
- DO THIS NOW!

GRAPH ANALYSIS

- WHAT DO YOU NOTICE?
  - WHEN ARE THE VALUES THE HIGHEST?
  - WHEN ARE THE VALUES THE LOWEST?

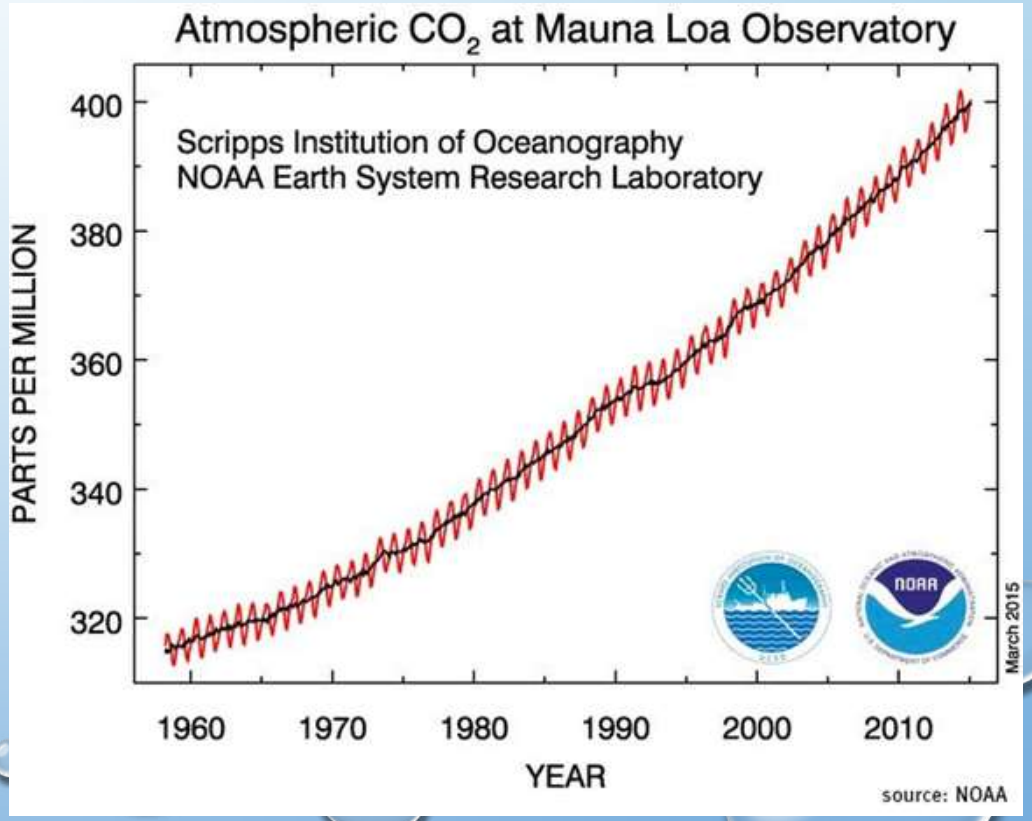


DATA ANALYSIS

- TAPE ALL OF THE GRAPHS TOGETHER IN CHRONOLOGICAL ORDER
  - OVERLAPPING THE "MONTH 0" AND "MONTH 12" TO CREATE A CONTINUOUS GRAPH OF MULTIPLE YEARS' DATA.

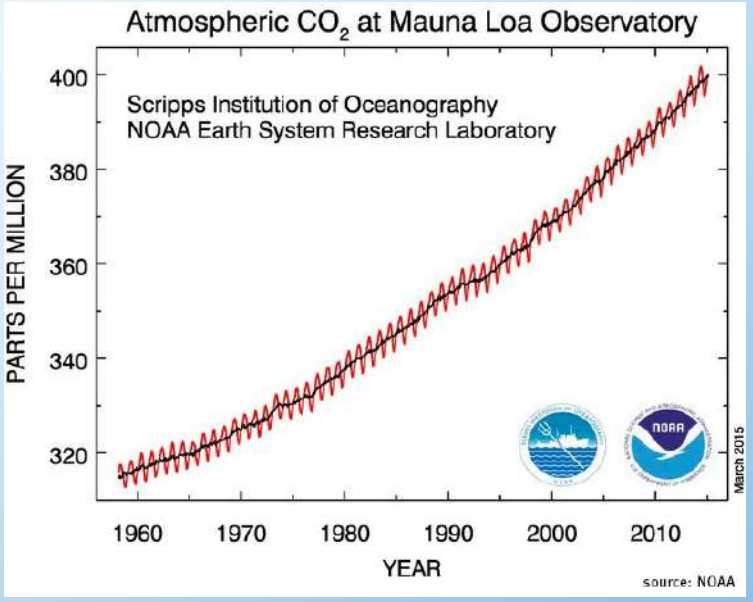
DO THIS NOW!

- WHAT DO YOU NOTICE?



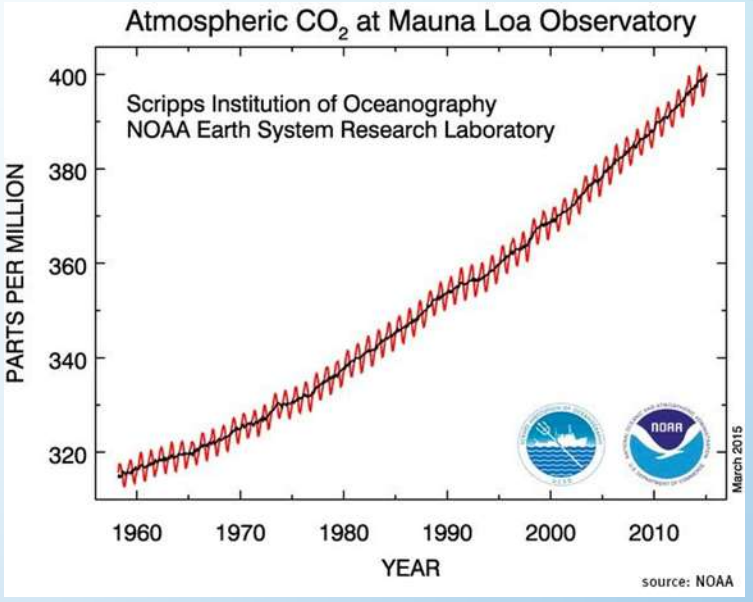
SEASONAL VARIATION

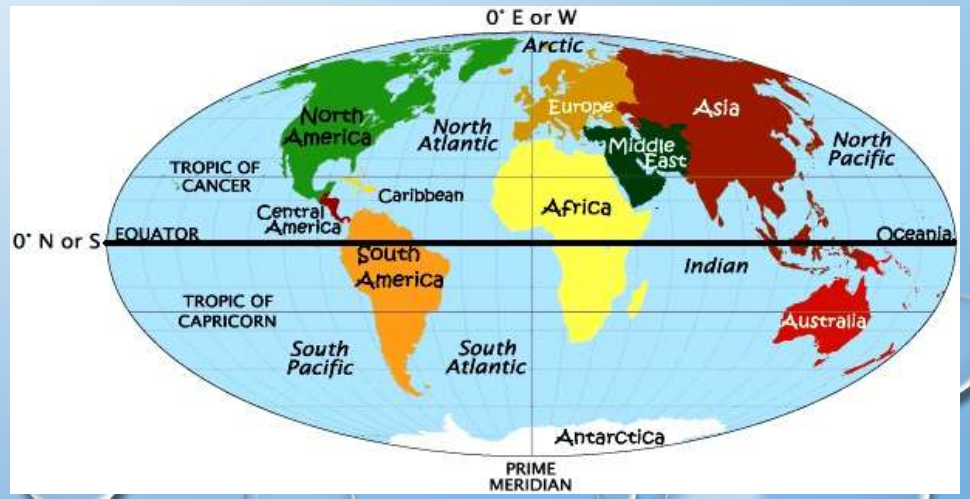
- DIRECT MEASUREMENTS OF ATMOSPHERIC CARBON DIOXIDE (CO_2) CONCENTRATIONS HAVE BEEN RECORDED AT MAUNA LOA SINCE 1958. ITS MID-PACIFIC LOCATION MAKES IT AN IDEAL PLACE TO COLLECT ATMOSPHERIC DATA.
- THE UNITS OF ATMOSPHERIC CARBON DIOXIDE MEASUREMENTS ARE PPM — PARTS PER MILLION.
  - FOR EVERY MILLION MOLECULES OF AIR IN OUR ATMOSPHERE, SOME NUMBER OF THEM ARE CARBON DIOXIDE MOLECULES.
- SINCE 1958, THE CONCENTRATION OF ATMOSPHERIC CO_2 HAS RISEN FROM 315 PPM TO OVER 403 PPM (AS OF MARCH, 2016). THIS IS DEPICTED IN THE GRAPH, KNOWN AS THE KEELING CURVE.
- THE KEELING CURVE IS NAMED FOR CHARLES DAVID KEELING OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY, WHO WAS THE FIRST PERSON TO MAKE FREQUENT REGULAR MEASUREMENTS OF ATMOSPHERIC CO_2CONCENTRATIONS AT MAUNA LOA.



SEASONAL VARIATION CONT…

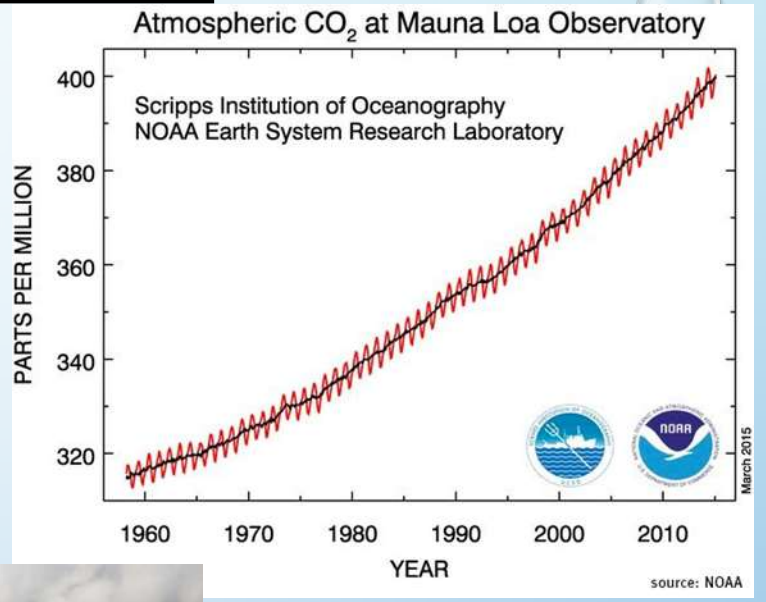
- THE PERIODIC ANNUAL FLUCTUATIONS IN THE GRAPH REFLECT SEASONAL CHANGES.
- THE NORTHERN HEMISPHERE HAS FAR MORE LAND AREA THAN THE SOUTHERN HEMISPHERE, AND MOST OF THE LAND AREA IN THE SOUTHERN HEMISPHERE IS DESERT.
- AS PLANTS IN THE NORTHERN HEMISPHERE GROW LEAVES EACH **SPRING AND SUMMER**, THEY REMOVE SOME CO_2 FROM THE AIR VIA PHOTOSYNTHESIS, CAUSING CO_2 LEVELS TO DROP.
  - THERE IS A LAG TIME FOR THIS EFFECT TO SHOW IN THE DATA, SO THE LOWEST ANNUAL CO_2 CONCENTRATIONS OCCUR IN THE FALL.
- DURING NORTHERN HEMISPHERE **FALL AND WINTER**, PLANTS LOSE THEIR LEAVES, AND THE DECREASE IN PHOTOSYNTHESIS CAUSES THE CO_2 LEVEL TO RISE.
  - THERE IS A LAG TIME FOR THIS CHANGE TO SHOW IN THE DATA AS WELL.
- THUS, HIGHEST CO_2 CONCENTRATIONS OCCUR IN MAY EACH YEAR. THIS SEASONAL FLUCTUATION IS THE NATURAL CYCLING OF CARBON FROM AN ATMOSPHERIC GAS TO SOLID PLANT MATERIAL AND BACK.





SEASONAL VARIATION CONT…

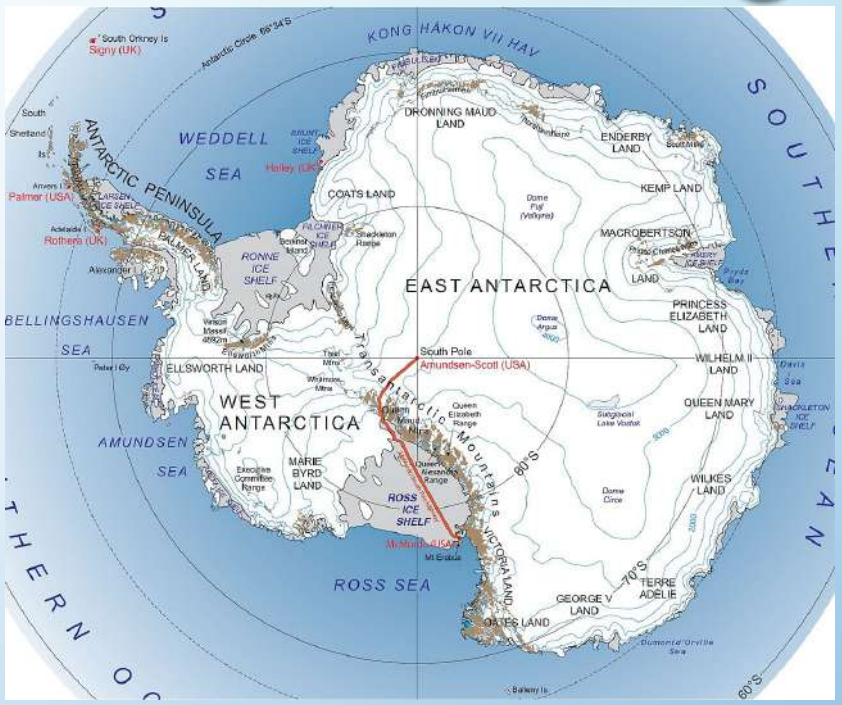
- WHEN YOU VIEW MULTIPLE YEARS OF DATA TOGETHER, THE OBVIOUS UPWARD TREND IS NOT PART OF THE NATURAL CYCLING OF CARBON BETWEEN THE ATMOSPHERE AND THE BIOSPHERE.
- **HUMAN ACTIVITIES ARE ALTERING THE CARBON CYCLE** — BOTH BY ADDING MORE CO_2 TO THE ATMOSPHERE AND, THROUGH LAND USE CHANGES SUCH AS DEFORESTATION, INFLUENCING THE ABILITY OF NATURAL SINKS, LIKE FORESTS, TO REMOVE CO_2 FROM THE ATMOSPHERE.
- WHILE CO_2 EMISSIONS COME FROM A VARIETY OF NATURAL SOURCES, HUMAN-RELATED EMISSIONS ARE RESPONSIBLE FOR THE INCREASE THAT HAS OCCURRED IN THE ATMOSPHERE SINCE THE INDUSTRIAL REVOLUTION (1760 - 1840).
- UNTIL THAT TIME, ATMOSPHERIC CO_2 HAD NOT BEEN HIGHER THAN 280 PPM. DIRECT MEASUREMENTS OF GAS BUBBLES IN ICE CORES FROM ANTARCTICA SHOW THAT ATMOSPHERIC CO_2 LEVELS DID NOT EXCEED 280 PPM DURING THE PREVIOUS 800,000 YEARS.
- THE MAIN HUMAN ACTIVITY THAT EMITS CO_2 IS THE COMBUSTION OF FOSSIL FUELS (COAL, NATURAL GAS, AND OIL) FOR ENERGY AND TRANSPORTATION, ALTHOUGH CERTAIN INDUSTRIAL PROCESSES AND LAND-USE CHANGES ALSO EMIT CO_2.



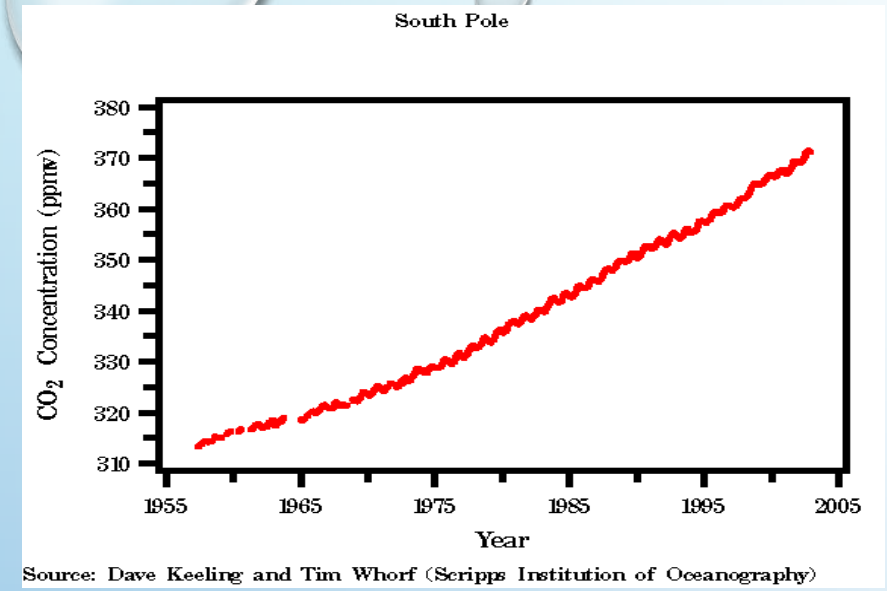
SOUTH POLE DATA

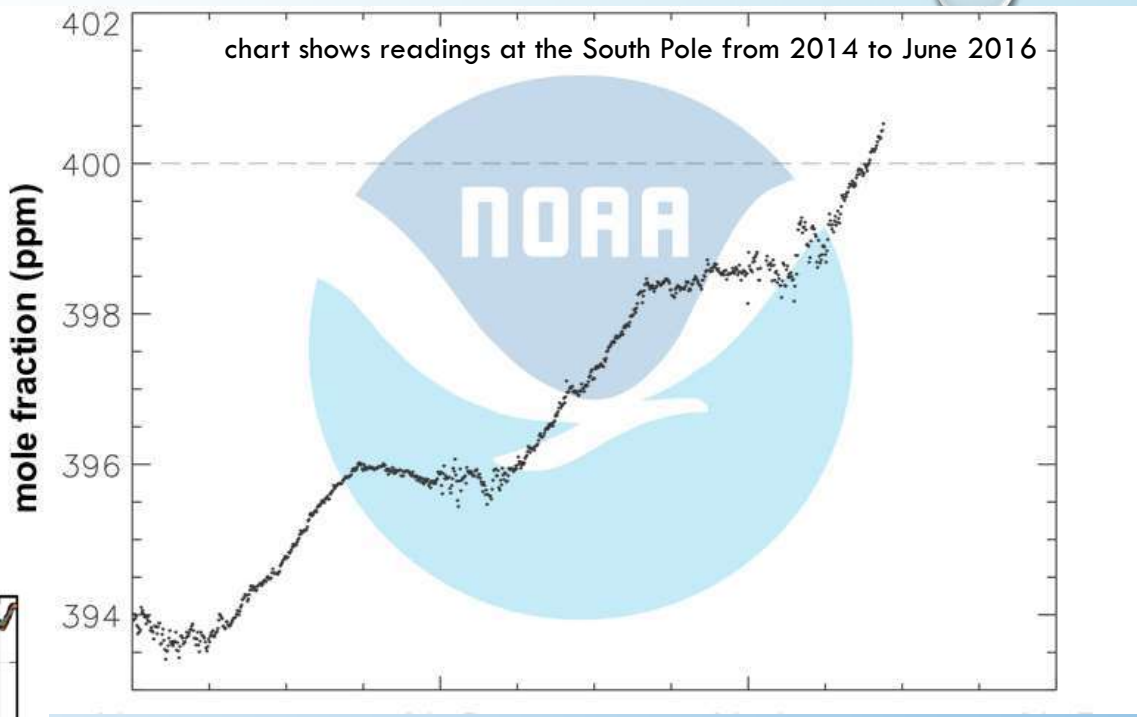
- NOW GRAPH THE SOUTH POLE DATA FOR 2008 – 2013
- DATA SHOULD BE ADDED TO THE SAME GRAPH PAPER
  - BE SURE THE DATA ARE FROM THE SAME YEAR
  - USE STICKY DOTS THAT ARE A DIFFERENT COLOR

DO THIS NOW…

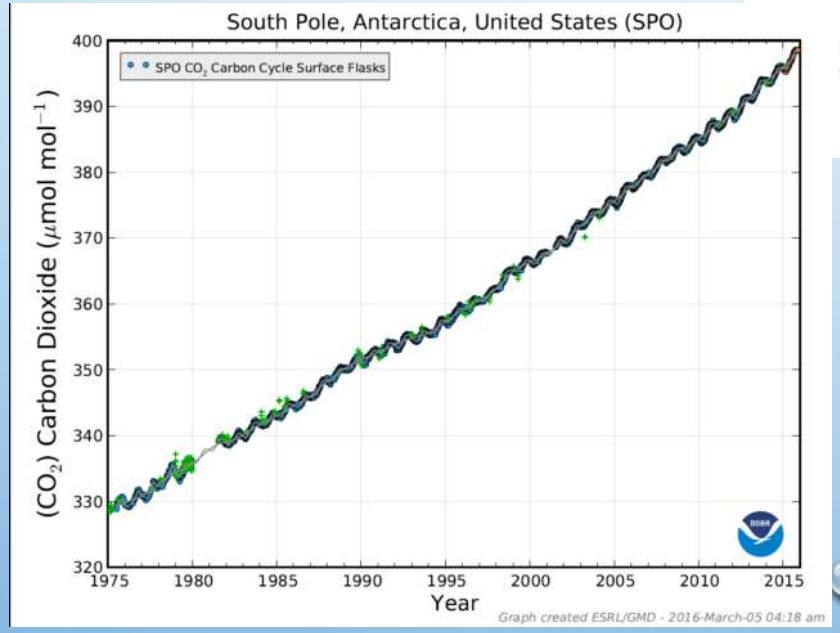


SOUTH POLE DATA

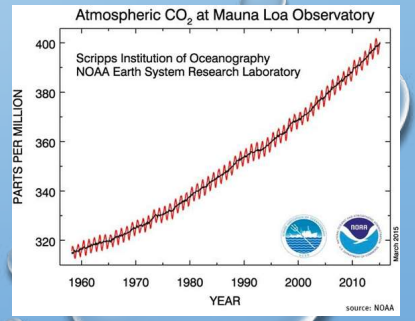




- What do you notice about the seasonal fluctuation pattern of the Northern Hemisphere and in the Southern Hemisphere?
- Why do think these different patterns occur in the data?

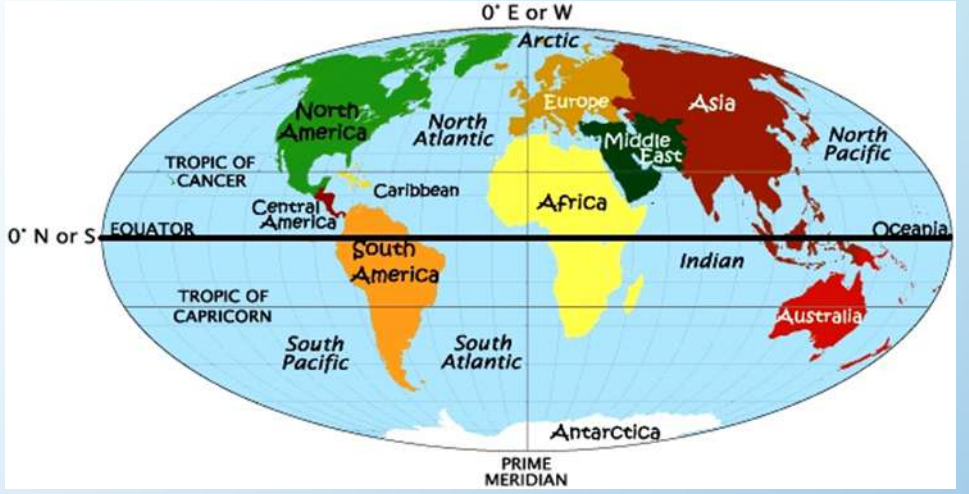


Mauna Loa Data



NORTH VS. SOUTH CO_2 VARIATION

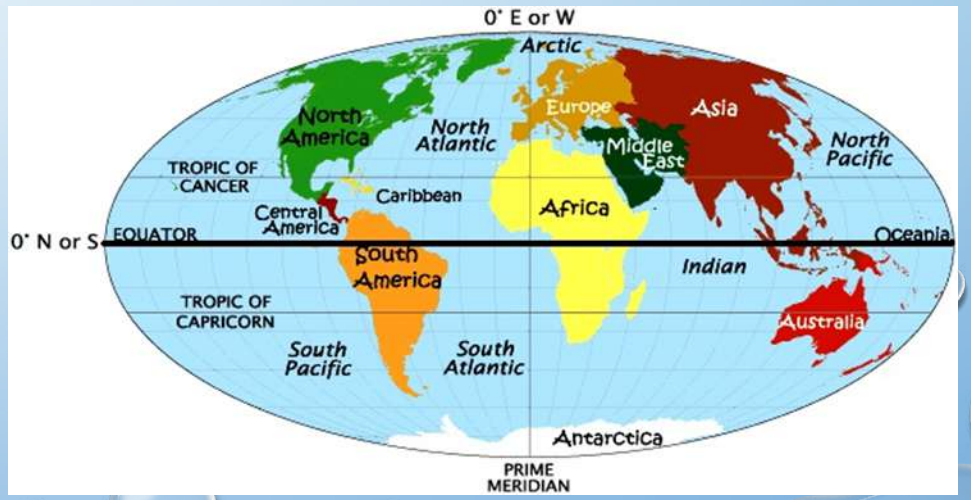
- RESEARCHERS FOUND STRONG SEASONAL CO2 FLUCTUATIONS THROUGHOUT THE NORTHERN HEMISPHERE AND WEAKER FLUCTUATIONS NEAR THE EQUATOR AND IN THE SOUTHERN HEMISPHERE.
  - THE STATION AT BARROW, ALASKA (71° N LATITUDE), FOR EXAMPLE, EXPERIENCES ENORMOUS SWINGS IN SEASONAL CO2. IN FACT, AT THIS SITE, THE DAILY 400 PART-PER-MILLION (PPM) BENCHMARK WAS PASSED FOR BRIEF PERIODS STARTING IN 2006.
  - AT THE OPPOSITE END OF THE SPECTRUM, AT THE SOUTH POLE (90°S LATITUDE) AND OTHER SITES IN THE SOUTHERN HEMISPHERE, THERE IS HARDLY ANY SEASONAL VARIABILITY.



- THESE LATITUDINAL DIFFERENCES IN FLUCTUATION ARE THE RESULT OF PHOTOSYNTHETIC ACTIVITY BY PLANTS.
  - AS PLANTS BEGIN TO PHOTOSYNTHESIZE IN THE **SPRING AND SUMMER, THEY CONSUME CO2** FROM THE ATMOSPHERE AND EVENTUALLY USE IT AS A CARBON SOURCE FOR GROWTH AND REPRODUCTION.
    - THIS CAUSES THE DECREASE IN CO2 LEVELS THAT BEGINS EVERY YEAR IN MAY.
  - **ONCE WINTER ARRIVES, PLANTS SAVE ENERGY BY DECREASING PHOTOSYNTHESIS.** WITHOUT PHOTOSYNTHESIS, THE DOMINANT PROCESS IS THE EXHALATION OF CO2 BY THE TOTAL ECOSYSTEM, INCLUDING BACTERIA, PLANTS, AND ANIMALS.

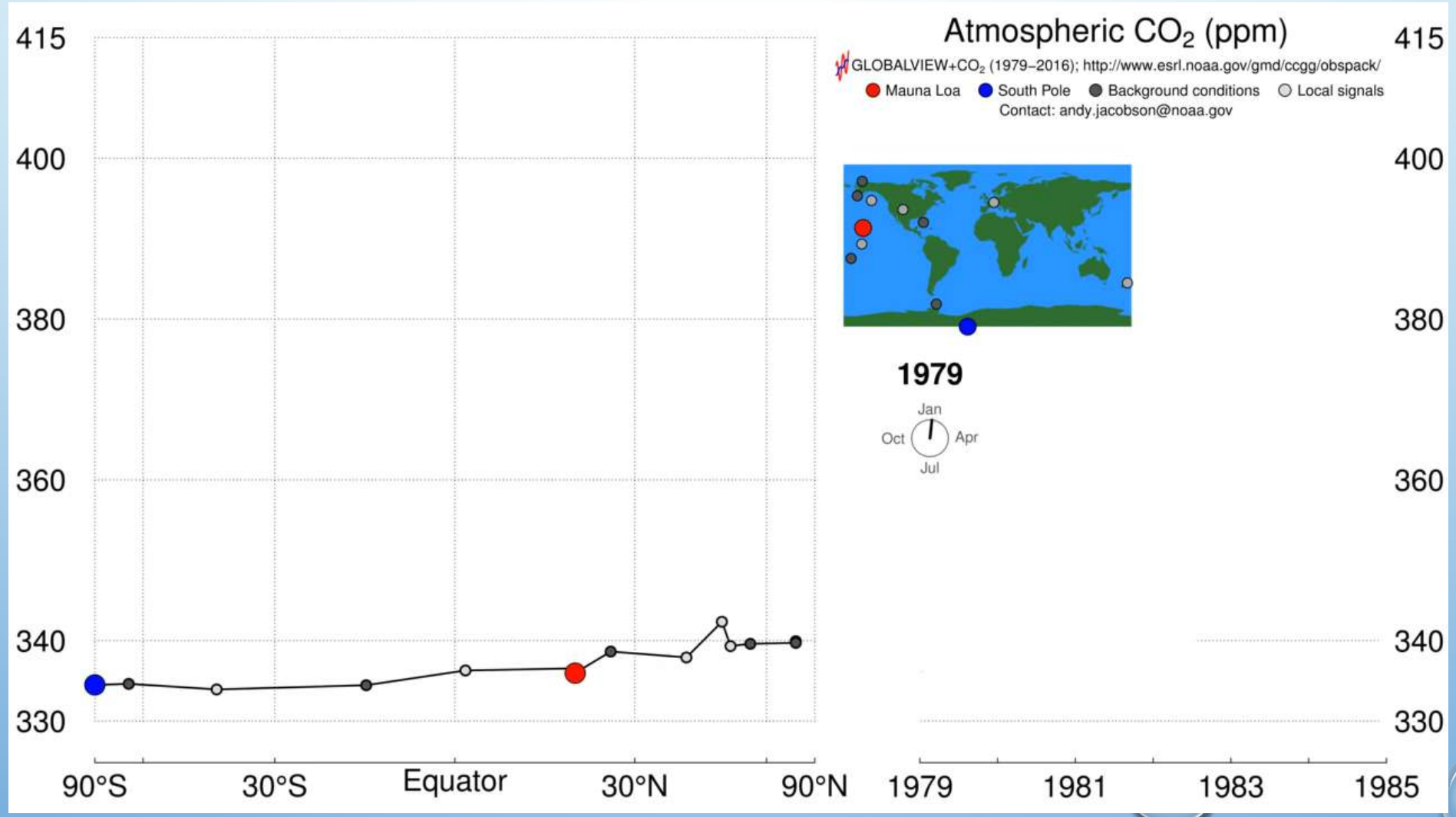
NORTH VS. SOUTH CO_2 VARIATION CONT…

- BECAUSE PHOTOSYNTHETIC ACTIVITY IS THE CAUSE OF SEASONAL CO2 SWINGS, REGIONS WITH MORE PLANTS WILL EXPERIENCE LARGER FLUCTUATIONS.
- PHOTOSYNTHESIS ALSO OCCURS IN THE OCEANS, BUT LITTLE OF THIS CO2 ACTUALLY MOVES INTO THE ATMOSPHERE, WHICH IS WHY ONLY LAND PHOTOSYNTHESIZERS DRIVE SEASONAL CYCLES.
- SEASONAL SWINGS IN CO2 ARE THEREFORE MOST PRONOUNCED IN THE NORTHERN HEMISPHERE, WHERE THE SEASONAL CHANGES IN TEMPERATURE RESULT IN VERY LARGE DIFFERENCES IN PLANT PHOTOSYNTHESIS FROM SUMMER TO WINTER.



CARBON TRACKER VIDEO

- HTTPS://YOUTU.BE/GH6FQH9EAQE

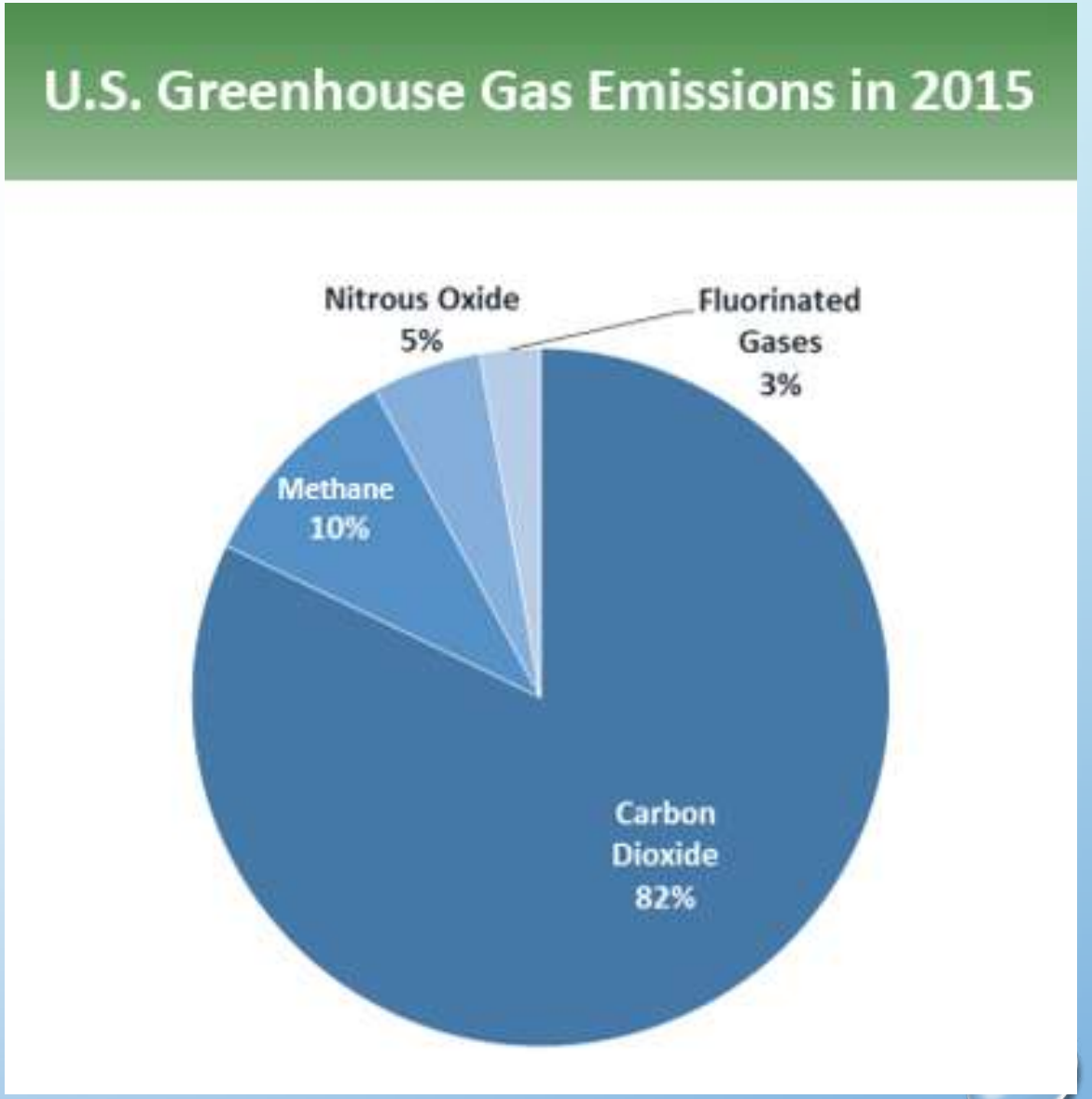


- **Carbon dioxide (CO2):** Carbon dioxide enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g., manufacture of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

- Methane (CH4): Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

- **Nitrous oxide (N2O):** Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

- **Fluorinated gases:** Hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes.

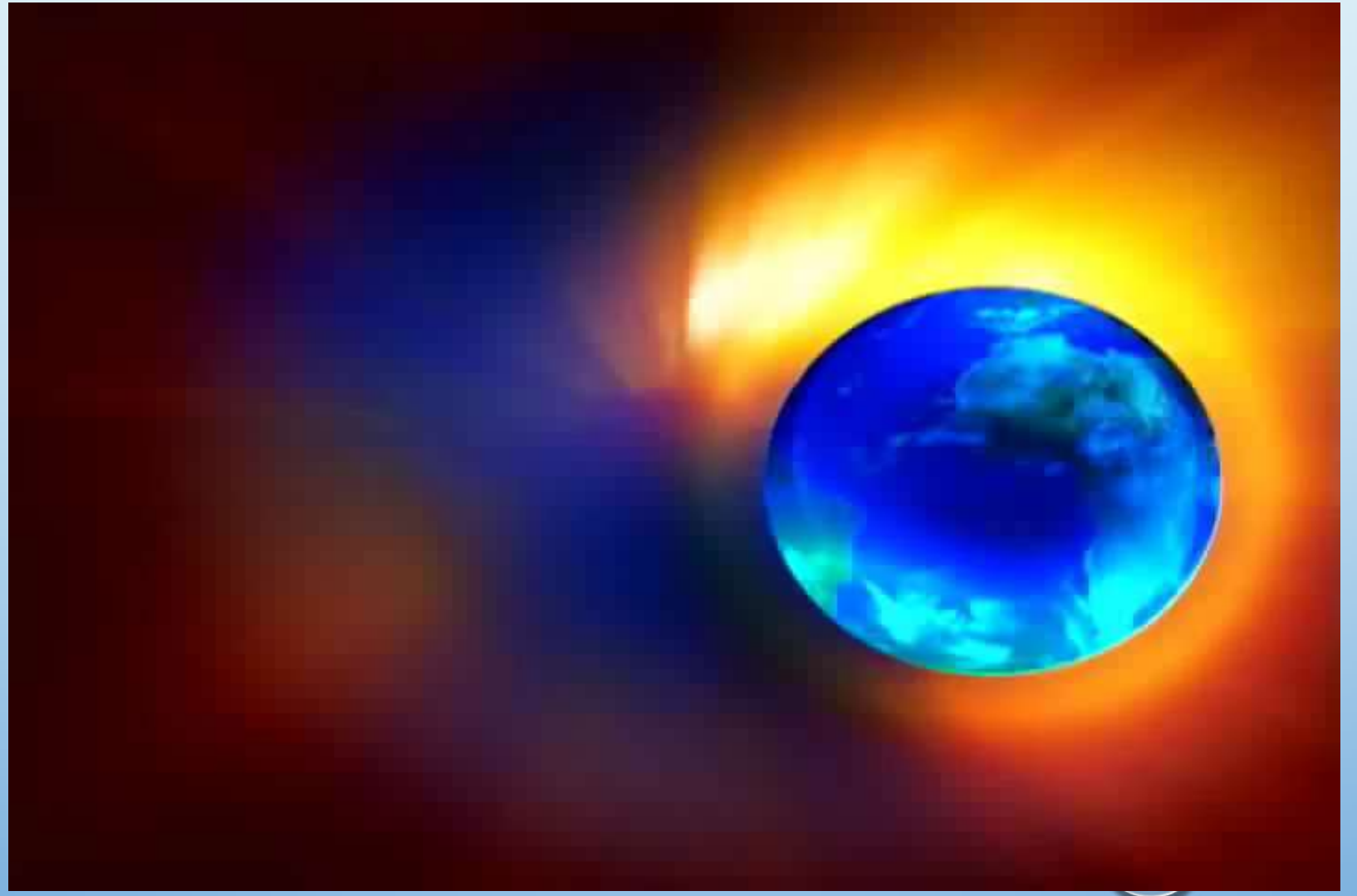


HOW DO GREENHOUSE GASES ACTUALLY WORK?

- HTTPS://YOUTU.BE/STVQIIJQVTG

GREENHOUSE GAS DEMO

- HTTPS://YOUTU.BE/KWTT51GVAJQ



CORRELATION BETWEEN CO2 & TEMPERATURE