GS106 Overview of Greenhouse Effect

I. Introduction

A. Infrared Active Gases ("Greenhouse Gases")
1. Water Vapor
2. Carbon Dioxide
3. Ozone

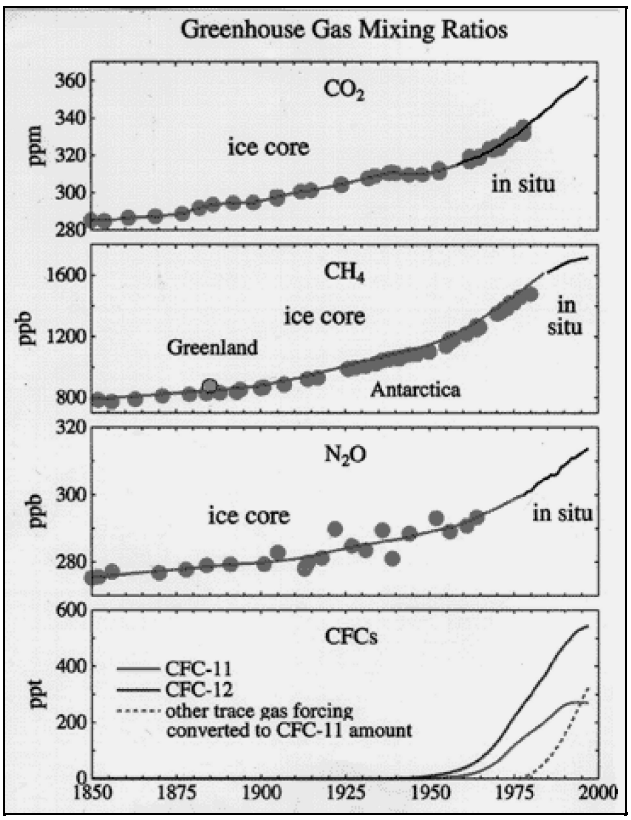
B. Greenhouse Process
1. Absorb Thermal Infrared Radiation (heat) reflected by Earth's surface and atmosphere

2. Atmospheric warming, warming of Earth surface, warming of lower troposphere

3. Net Result: average Earth surface temperature = 30^{o} C higher than it would be without the Greenhouse process

C. Historic Consideration
1. rapid increase in concentration of Greenhouse gases since the industrial period (1800's)

II. Greenhouse Gases and Earth-Atmosphere Energy Balance



A. Historic Greenhouse Gas Concentrations

1. Carbon Dioxide (CO_2)
a. concentrations
(1) pre-industrial concentration = 280 ppm
(2) post-industrial concentration (1997) = 364 ppm

b. Source: burning of fossil fuels
(1) Carbon Loading: 6.5 x 10^{15} g carbon / year
(2) loading exceeds uptake of carbon dioxide by atmosphere and oceans
(a) net result: > carbon dioxide concentrations

c. Carbon Dioxide Sinks (removal processes)
   (1) oceanic dissolution
   (2) burial in soils / deep sea sediments (calcium carbonate deposits)

d. Residence Times for Anthropogenic Input:
   (1) decades to centuries, with 15-30% remaining for thousands of years

2. Methane (CH_4)

a. concentrations
   (1) pre-industrial = 700 ppb
   (2) post-industrial (1994) = 1721 ppb

b. Source
   (1) fossil fuels
      (a) 70 - 120 x 10^{12} g CH_4 / yr
   (2) Agriculture, Landfills
      (a) 200 - 350 x 10^{12} g CH_4 / yr

c. Estimated residence time for anthropogenic input: 10 years in atmosphere

3. Nitrogen Oxide (N_2O)
   a. concentrations
      (1) preindustrial = 275 ppb
      (2) post-industrial (1994) = 312 ppb

   b. Source: agriculture and industry
      (1) 3-8 x 10^{12} g N / yr

B. Greenhouse Processes
   1. anthropogenic greenhouse gas increases atmospheric absorption of Infrared Radiation
      a. result:
         (1) warming of troposphere and Earth surface
         (2) cooling influence on stratosphere

      b. Carbon Dioxide: most long-lived greenhouse gas in atmosphere, most important factor

   2. Complex Feedback and Response
      a. global warming, induces increased evaporation, increases water vapor, increases cloud cover, increases albedo, promotes cooling
      b. local vs. global response
      c. feedback systems uncertain, complex interaction of variables

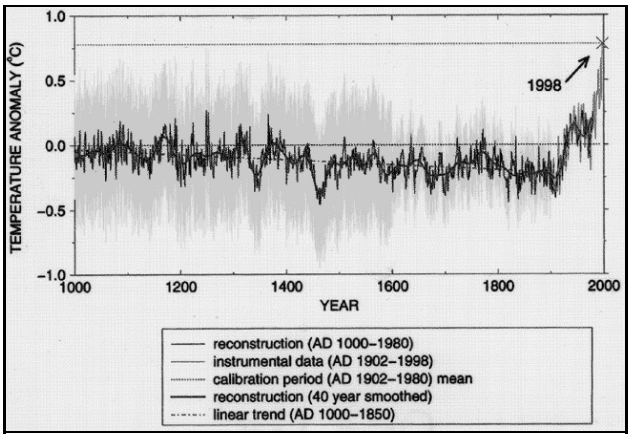
III. Climate Change and Carbon Dioxide Content

A. Surface Air Temperature

1. historic global temperature monitoring
    a. results: increase of 0.3 to 0.6 degree C over past 150 years
    b. temperature increase is variable, this is a long term average trend

B. Climate / Temperature Proxy Data

1. tree ring records
2. ice sheets / ice caps / Glaciers
    a. present on every continent except Australia
    b. geographically distributed / regional climate indicators
    c. NOTE: glaciers have been notably receeding for the past century (globally)
3. Ice Records over past several centuries (pre-industrial greenhouse gas influx)
    a. show variations in global warming and cooling w/o anthropogenic influence
    b. RESULT: many variables influence climate, not just greenhouse gases
    c. Carbon Dioxide Records (ice bubbles)
        (1) natural variation in atmospheric CO2 = 80 - 100 ppm +/-
        (2) glacial climate correlates to low CO2
        (3) interglacial climate correlates to high CO2



C. Disussion

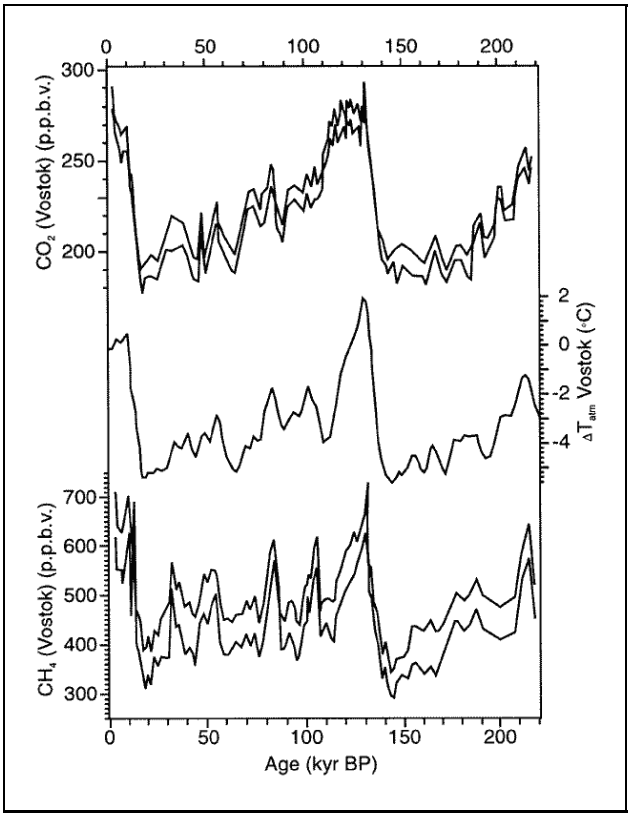
1. paleoclimate data suggests there is natural variation of greenhouse gases, outside the influence of anthropogenic activity
2. there is definitely a link between carbon dioxide content and atmospheric heating / cooling
3. many variables exist in a complex system
4. historically: there is definitely a dramatic increase in CO2 levels in atmosphere

IV. Global Response to Climate Change and Greenhouse Effect

A. Anticipated Effects - Results of Modeling Studies

1. increase in mean air temperature
    a. doubling CO2 content === increase of 2 deg. C
2. increase in levels of evaporation and precipitation
    a. increased heat in atmosphere
    b. increased evaporation
    c. increased rainfall / storm intensity
    d. increased flooding
3. melting of ice sheets
    a. e.g. Greenland Ice Sheet: thinning of ice sheet in past decade by up to 1 m/yr at lower elevations

4. rising sea level
    a. tide records for past century
        (1) mean sea level rise of ~ 18 cm /100 yrs
    b. thermal expansion
    c. volume increase
5. changes in biosphere / ecosystems
    a. increase in active growing season at high latitudes



V. Summary Points
    A. Anthropogenic greenhouse gases have increased significantly during the industrial period
    B. Effects of greenhouse gases expected to exist for up to 1000's of years
    C. Increased greenhouse gases cause > infrared absorption, and heating of atmosphere
    D. Global mean air temp. have > 0.3 - 0.6 C in past 150 years
    E. Over the past thousands of years, climate has changed with little change in CO2 content
    F. Anticipated changes in system due to global warming include:
        1. increased air temperature
        2. increased precipitation and evaporation
        3. rising sea level
        4. changes in biosphere