Global warming

The last one or two decades have seen extensive debate over the likely consequences of the observed increase in CO_2 content of the atmosphere, CO_2 being one of the principle greenhouse gasses in the atmosphere.

Year	ppm CO_2
1860	~285
1960	~315
1992	~350
1998	~365

Increases in CO_2 in the atmosphere are a consequence principally of the burning of fossil fuels, although deforestation in tropical regions may also be a cause. Approximately 50% of the CO_2 we put in the atmosphere remains there (the rest being absorbed by oceans).

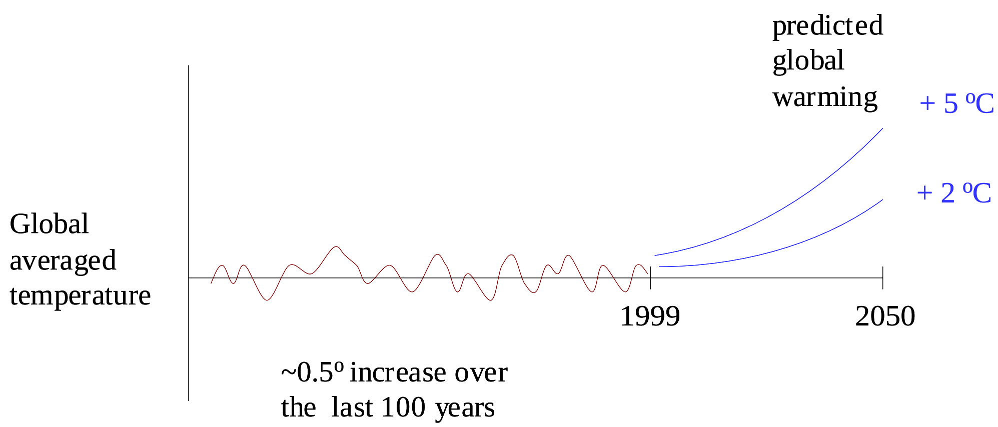
The anticipated increase in CO_2 is approximately a doubling of the current 350 ppm over the next 100 years. General circulation models (GCMs) predict that this would increase global temperature by 2 to 5 ^oC. There is, however, much uncertainty because there are many feedback effects that are not well understood and which are difficult to predict. For example, GCMs tend to handle cloud formation and precipitation poorly. Would the likely increase in cloud cover have a net positive or negative feedback to the warming process?

Also of great importance is the fact that increased human activity is likely to increase particulate matter in the atmosphere. The primary effect of particles is to reflect incoming solar radiation back to space, thus decreasing solar heating of the earth and its atmosphere. Some believe that particulates will fully counteract greenhouse warming, but the majority of scientists involved in this question feel that global warming will indeed occur.

Other gasses N_2O, CH_4 and chlorofluorocarbons (CFC_s) are also increasing in the atmosphere and their combined effect is expected to equal that of CO_2.

Has global warming started?

Here, there is much argument because likely effects might be buried in climatic "noise" or natural uncertainty in the climate system. Also entering the problem is the possibility of systematic errors in the measurements, such as increased carbonization in the vicinity of climate stations.



The behavior of gasses in the atmosphere (atmospheric thermodynamics)

Thermodynamics is the study of the relationship between mechanical work and the internal energy of a gas (its heat content)

The state variables

State: The condition of the system (or part of the system) at an instant oftime measured by its properties.

The thermodynamic properties of a gas are specified by the three state variables:

1. Pressure p
2. Temperature T
3. Density ρ
   (or its inverse, specific volume α)

Pressure

is force per unit area exerted by the molecular motions of a gas.

Units: a) the unit of force in the MKS system (SI) is the Newton (N) ≡ kg m s^{-2}
(F=ma, mass x acceleration)

A force of 1 N will cause an acceleration of 1 m s^{-2} in a mass of 1 kg

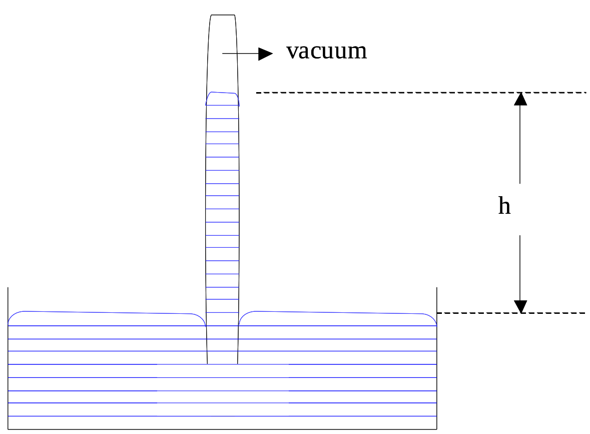
b) the unit of pressure is Newtons per square meter, which is called the Pascal (Pa).

1 Pa ≡ 1 N m^{-2} ≡ kg m^{-1} s^{-2}

c) the common meteorological unit of pressure is the millibar (1 bar/1000). The conversion to Pa is as follows:

1 mb ≡ 100 Pa
So, 1000 mb ≡ 100 k Pa (kilopascals)

d) other units in common usage are inches or cm of mercury (the height of a column of mercury in a barometer)



A “standard atmosphere” pressure is the globally averaged MSL atmospheric pressure and is numerically equal to

A standard atmosphere
= 1013.25 mb
= 1013.25 h Pa (hecto Pascal)
= 101.325 k Pa
= 76.0 cm of Hg
= 29.92 inches of Hg
= 14.7 lb/sq inch

See chart of the range of atmospheric pressures experienced.

Temperature T

The degree of hotness, which determines the direction of heat transfer (hot to cold). It is related to the internal energy of a body or mass of material.

(Units: ^{o}C, ^{o}F, K)

Density ρ

is mass per unit volume (kg m^{-3})

$\alpha = 1/\rho$ is volume per unit mass (m^3 kg^{-1})