GLOBAL WARMING COMPUTER LAB

A COMPUTER SIMULATION PROGRAM ON TEMPERATURE CHANGE AND SEA LEVEL RISING

After performing this computer simulation lab you will be able to:

1) understand the greenhouse effect and its implications for the future of our planet
2) vary one or more of the principal factors affecting temperature and sea levels and observe projections for the next decades
3) observe the effects of future rise in temperature on sea level at selected localities
4) understand the worldwide effects of large volcanic eruptions on climatic change

EXPERIMENTS

1) GLOBAL TEMPERATURE AND SEA LEVEL CHANGES
   Describe predicted changes on temperature and sea level from five different experimental runs. Change different variables for each experiment. Keep a record of the changes. Print your results.

2) LOCAL EFFECTS
   a) Describe the predicted temperature and sea level change for 5 different regions of the United States
   b) Explain the temperature and sea level change at different cities in the US
   c) Explain the world map of temperature change
   d) Using 5 different values on sea level rise, explain what will happen to the coastal areas of the US
   e) Describe the effects of sea level changes at different coastal cities within the US

3) GLACIERS
   Describe the process of glacier thinning and its relationship to global warming and sea level rising.

4) VOLCANIC ACTIVITY
   a) How does sulfuric concentrations compare between the Northern and Southern Hemispheres?

b) What volcanic eruption produced the most prolonged cooling period?
c) What happened after the Mt. Pinatubo eruption with the cooling effect?
d) Describe the temperature changes by volcanism with amounts of aerosols. Use at least 5 different values in your experiment.

EQUATIONS

HOTHOUSE PLANET uses the following equations to calculate the temperature change projected to occur as a result of values entered for the variables.

$$\mathbf{C} = CD - C_o$$

$$\mathbf{F} = 7.92 - 0.000566\,C + 1.59\,A$$

$$\mathbf{G} = \frac{0.0706C}{(1+0.0022C)^{0.6}} + 864\,\frac{S - S_o}{S_o} - 65A - 5.7A^2 + P - P_o$$

$$\mathbf{P} = 3.25M^{0.5} + 16N^{0.6} - 0.325MN + 0.855C_1 + 1.03C_2$$

$$\mathbf{T} = [(F^2 + G)^{0.5} - F]\,T_E - 0.1599$$

$$\mathbf{X} = \text{INT}\,(T \times T_E \times 100 + .5)/100 - 0.65$$

Constants: $T_E = 4.2$ (sensitivity of model to doubled CO_2)
$S_o = 1$ (initial value for solar irradiance)
$P_o = 10.2885$ (initial value CH_4, N_2O and CFCs effect on temperature)
$C_o = 297$ (CO_2 in 1880)

Variables: $CD = CO_2$ concentration in ppm
A = value for volcanic aerosols
S = value for solar irradiance
$M = CH_4$ concentration in ppm
$N = N_2O$ concentration in ppm
C_1 and C_2 = CFC concentration in ppb (see Note)

Results: T = temperature change from 1880's
X = temperature change in 1989
C, F, G and P are quantities used internally in the calculation.
INT represents integer function.

Note: C_1 and C_2 represent the two principal chloroflurocarbons, CCl_2F_2 and CCl_3F. Total concentration is assumed to be divided equally between the two.

GLOSSARY

Blackbody – an ideal radiating surface from which the total amount of energy emitted as electromagnetic radiation depends solely on the surface temperature. The energy radiated is proportional to the fourth power of the surface's absolute temperature i.e. temperature in Kelvins.

Carbon dioxide (CO_2) – the most important and abundant greenhouse gas, accounting for about two-thirds of the greenhouse effect. The 25% increase in CO_2 since 1880 is attributed principally to combustion of fossil fuels and deforestation.

Chlorofluorocarbons (CFCs) – gases that are compounds of carbon, fluorine and chlorine. In addition to contributing to greenhouse warming, CFCs deplete stratospheric ozone, which leads to increased harmful ultraviolet radiation at the Earth's surface. CFCs are used as refrigerants, aerosols, insulating material, and solvents.

Greenhouse Effect – the increase in global surface temperature brought about by the absorption by trace gases of heat radiated from the Earth's surface.

Methane (CH4) – a hydrocarbon also known as natural gas. Sources include ruminant livestock, rice paddies, biomass burning, coal mining, oil production, landfills, and wetlands.

Nitrous Oxide (N2O) – a colorless gas derived from fossil fuel and biomass combustion, fertilizers, landfills and coal seams.

Optical depth – the extinction coefficient of radiation, i.e., the fractional amount that is removed (either scattered or absorbed) as solar radiation passes through stratospheric aerosols. Optical depth (tau) is a dimensionless quantity. Change in tau is calculated by $I = I_o e^{-t}$, where I is intensity of solar radiation after passing through the stratosphere; I_o is the intensity of solar radiation entering the stratosphere; and t is the optical depth.

Solar irradiance – the average amount of energy received at the top of the Earth's atmosphere at the mean earth-sun distance. Less solar irradiance means lower global temperature; greater solar irradiance means higher temperature.

Thermal (heat) radiation – radiation from the Earth's surface and atmosphere of infrared or longer wavelength energy.

Trace gases – gases which are present in the atmosphere in very low concentration.

Troposphere/Stratosphere – the troposphere is the lower atmosphere, from the ground to an altitude of about 8 km at the poles, 12 km in the mid-latitudes and 18 km in the tropics. The stratosphere extends from the upper troposphere boundary to about 50 km. The troposphere and stratosphere together contain more than 99.9% of the mass of the atmosphere.

Volcanic aerosols – fine solid or liquid particles suspended in the atmosphere as a result of volcanic eruptions.