**Chapter12**

* Greenhouse Gasses:   
    
  *Carbon Dioxide (CO2) 🡪 Biggest Cause of GHG effect, Comes from Fossil F Combustion  
  Methane (CH4) 🡪 Decomposing landfill, animal digestive tracts, gas production and coal   
  Nitrous Oxide (N2O) 🡪 Nitrogen containing Chemical fertilizers  
  CFC-11, 12, 113 🡪 Halocarbons, Refrigeration systems and aerosol cans, Banned  
  HCFC-22🡪 Perhalogens, industrial applications, increased after ban of CFC’s*
* What is GHG effect?  
    
  *Atmospheric absorption of outgoing IR radiation from earth. The energy absorbed will reradiate back to earth by greenhouse gas molecules. Warms earth beyond equilibrium of -19 degrees Celsius. Presently, GHG’s responsible for a warming of 34 degrees Celsius. This is therefore a natural occurrence to have in order for life to exist as it is now on earth. The problem is that GHG’s are increasing which subsequently is increasing the temperature of the earth. This is the environmental concern we face and what needs to be done is a stabilization of greenhouse gasses.*
* Climate:   
   *Climate is more stable than weather. It varies over longer period. (Average of 30 years needed usually to calculate average climate of a region.) Radiative heat exchanges govern climate temperature.*
* Heat Flux:   
    
  *Qmax(Dot)=sigma(A)(T)4 , where Q is maximum rate of energy radiated, sigma Stefan-Boltzmann constant, T absolute Temp in Kelvin, A area  
    
  q(dot) = Heat Flux=Qmax/A (W/m2)   
    
  🡪Shows recent decays and discrepancies,*
* Blackbody Radiation:  
    
  *Sun= 5800K 🡪 So=solar input, 342 W/m2 averageEarth🡪* *Te4 = Temperature of earth W/m2*  
    
  *These bodies will emit EMW with lambda = C/V  
    
  and lambda(max) = 2898/T*
* Troposphere:  
    
  *- Average Height= 10km  
  - contains 80 percent of the mass of all atmospheric gasses  
  - N2, O2 and traces gasses (water vapour, argon and CO2)*
* Stratosphere:   
   *- Atmospheric region above troposphere  
  - Oxygen O2 and Ozone O3 which absorb incoming UV radiation.   
  - Protects earth’s surface from damaging high-energy radiation UV-C (.20-.28um) and UV-B (.28-.32um).*
* Outgoing Waves:  
    
  *- Infrared (.4 and .7 um.)  
  - Captured by CO2 and H2O water vapour.*
* Solar Energy Waves:  
    
  *- So which comes as UV waves. (7um and 3um)  
  - Absorbed by O2 and O3.*

* Earth Energy Balance:  
    
  *-Simple. Overlay of wavelengths therefore figure 12.4 is not correct  
  - Better. Figure 12.  
  - Actual Figure 12.8.*
* Radiative Focing:   
    
  What is it?   
   *- Any change in the average net radiation (delta qdot) at the tropopause is delta F.  
  - It is used because any change in Radiative balance will force climate system to readjust in order to restore equilibrium.*How is it produced?  
    
  *1. By changing solar input radiation 🡪 Increase would mean positive forcing (warm)  
  2. Changing Albedo 🡪 melting of ice sheets would mean positive Radiative forcing because less radiation would be reflected back to space.  
  3. Addition of aerosols (suspension of fine particles less than 10um in dia, most important are ones from combustion of biomass and fossil fuels) in the atmosphere.  
  🡪 tend to reflect incoming solar radiation , negative feedback (cold)   
  -Figure 12.9 & 12.10*
* Equivalent CO2:  
    
  *- Quantifying the combined effects of multiple atmospheric constituents.   
  - Total Radiative Forcing from multiple greenhouse gasses can be expressed as an equivalent CO2 that would produce an overall forcing.*
* Sensitivity Factor:  
    
  *- The change in surface temperature of the earth over change in Radiative forcing at top of troposphere. (page 499)   
  -Gamma is important since and results from data show that it goes from 0.55 to 0.65 C/ W-m-2. Therefore a positive feedback currently exists (warming effect).*
* Climate Model:   
    
  *- GCM (General Circulation Model) which accounts for the complex physical and chemical processes that govern the atmosphere. These models have the principles of conservation of mass, momentum exchange and energy conservation as a basis.  
  - A doubling of CO2 would mean an increase of 2.5 degrees. This is another measure of climate sensitivity that is used with GCM’s.*
* Climate Change Predictions and Temperature change since preindustrial times:   
   *- Figure 12.  
  - Equivalent CO2 has risen drastically since last century.   
  - Prediction is that temperature is increasing at higher rate.*
* Historical Observations:   
    
  *- Measures have been made to deduce past climate trends going back millions of years.  
  - Vostok, Antarctica test station Analysis of core samples provides dramatic climate evidence over past 420 000 years.  
  - For most of the million years, Earth has always been much colder. Since last ice age   
  (10 000 years ago) earth Temp relatively stable, until now. CO2 and other gases is increasing inside Ice Cores samples.*
* Greenhouse Gasses Lifetime  
   *The longer the atmospheric lifetime of a substance, the more difficult the stabilization objective becomes. Water Vapour for example has a short lifetime; subsequently aerosol particles have a short atmospheric lifetime as well. Yet CO2 can stay and accumulate for thousands of years.*
* The carbon cycle:   
    
  *- CO2 is very stable and non-reacting chemical.  
  - Figure 12.21 shows the cycle.   
  - Was balanced over thousands of years until human activity disrupted the system by extracting carbon from the earth’s crust (fossil Fuels) and injecting it in the atmosphere.  
  - From Bern model, of the Anthropogenic CO2 added to the, half will remain even if emissions were to completely cease. This is why the policy goal worldwide is to stabilize CO2 emissions. Diminishing is widely seen an unrealistic strategy which is not likely to occur in our lifetime.*
* GWP:   
    
  *- Global warming potential is very powerful tool, since this is universally accepted.  
  - It shows how bad the situation is.*
* Calculation of Equivalent CO2 Emission Rate for Worldwide Greenhouse Gasses:  
   *- Assignment 1 shows how.*