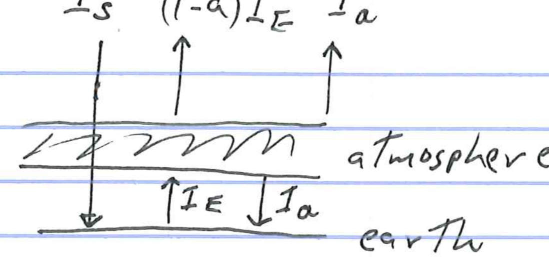
Global Warming



Sunlight passes through atmosphere, intensity I_S absorbed by earth (reflected light not included in I_S).

Earth radiates in IR with intensity I_E; a fraction a of this IR radiation is absorbed by atmosphere.

Atmosphere radiates intensity I_a both into space and down to earth. Earth absorbs radiation from atm.

Earth in equilibrium: $I_E = I_S + I_a$ (absorbed intensity matches radiated intensity).

Intensity emerging from atm matches intensity incident from sun:

$$I_S = I_a + (1-a) I_E$$

Eliminate I_a: $I_S = (I_E - I_S) + (1-a) I_E = (2-a) I_E - I_S$

$$\Rightarrow I_E = \left(\frac{2}{2-a}\right) I_S$$

Limiting cases: $a=0 \Rightarrow I_E = I_S$ (earth radiates at rate it absorbs.)

$a = 1 \Rightarrow I_E = 2 I_S$ (Now radiation from atm matches solar intensity. On earth, equal intensity from sun and atm.)

a is increasing as CO_2 in atm increases $\Rightarrow$ earth warms: We know

$a \simeq .75$, $a_{CO_2} \simeq .07$, $a_{CO_2} \propto$ concentration n_{CO_2}

$n = 400$ ppm

$\Delta n = 2$ ppm/yr $\Rightarrow \Delta T_E \sim .02°/\text{yr}$

Why? $I_E = \sigma_B T_E^4 \Rightarrow T_E \propto \left(\frac{2}{2-a}\right)^{1/4}$

$$\Rightarrow \Delta T_E = \Delta a \, \tfrac{1}{4}(2-a)^{-1} \, T_E \simeq \tfrac{1}{5} \Delta a \, T_E$$

$(a \simeq .75)$

$$\Delta a_{CO_2} = a_{CO_2} \, (\Delta a / a)_{CO_2}$$

$$= .07 \, \frac{2 \text{ ppm}}{400 \text{ ppm}}$$

$$\Rightarrow \Delta T_E = \tfrac{1}{5}(.07) \frac{2}{400} (T_E \simeq 300°K)$$

$$\simeq (7 \times 10^{-5})(300) \simeq .02°/\text{yr} \; (°C)$$

Earth warms 1°C in 50 years, assuming $\Delta n = 2$ ppm/year and $a_{CO_2} \propto n_{CO_2}$.

(Of course, model is vastly oversimplified...)