CivE 230 Assignment 2

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Assignment 2

Part 1 - Theory

1. **Radiative forcing** is any imposed alteration of the earth's balance between absorption of solar radiation and emission of infrared emissions. Following this alteration, the Earth's temperature adjusts to bring it back into balance. Humans have caused radiative forcing by releasing greenhouse gases. Some of these gases remain in the atmosphere for prolonged periods of time, and absorb of the infrared emissions and solar radiation. This leads to increased heating of the Earth, as the Earth attempts to bring itself back into balance.
2. The Global Energy Balance (GEB) overlooks the upper level atmosphere, lower level atmosphere, the the wavelengths of transmitted energy. The upper level is significant because it consists of ozone. Ozone absorbs UV rays coming from the sunlight, and also allows for absorption of infrared emissions being released. When holes in the ozone layer started to appear, more infrared emissions were allowed to be released, yet they were not accounted for in the GEB. The lower level atmosphere is very significant because it consists of greenhouse gases. Thus, the GEB did not account for anthropogenic contributions to this layer. Lastly, the equation doesn't consider the wavelength of the radiation. This is significant because it would impact the energy being released
3. **Carbon intensity** is the mass of C released per energy unit (J) delivered. For example, oak wood produces ~ 100 000 $\frac{KGCO_2}{TJ}$
4. **Global Warming Potential (GWP)** is a factor that compares the total warming impact of a GHG to that of CO_2. It is determined based on the lifetime of the GHG in the atmosphere, as well as their respective warming impact. They are updated by scientists every few years based on new research to the lifetime of chemicals and their respective warming impacts.
5. Both mitigation and adaption is required. Mitigation is proactive, as it would reduce the amount of adaptation required. However, there is still inevitable change, and for that humans need to adapt. Four Canadian provinces have signed the Western Climate Initiative to reduce emissions. Something that has helped with mititagion is the use of energy-efficient vehicles and smarter transit modes. In Canada, tax credits are high as $15 000 are being given to those who drive electric or hybrid vehicles, and technologies like ION trains are being explored. In order to adapt, more resilient utilities are being build. Nuclear power plants, for example, are designed for incredible storms.
6. **Criteria pollutants** are pollutants that would specifically be harmful to one's health and the environment. For these pollutants, companies have to meet the specified criteria on emissions.
7. This characterization suggests that vulnerable people are at a higher risk at the specified pollution range than the general public. For example, someone who is asthmatic would have a harder time than someone who is

non-asthmatic.

8. The Gaussian Plume model is highly appropriate for modelling point-source emissions. This is because it models the concentration of pollutants with some realistic assumptions, resulting in a model that requires a simply calculation. Models require simplifications, as without such, they would be much harder to use. This model uses a single formula, which can quickly be solved by hand or using programming.

(9) $T_2 = 291\,K$ $\sigma = 5.67E{-8}\ \frac{W}{m^2K^4}$

$100\,W/m^2$ reflected.

$30\,W/m^2$

a) Incoming − Atmosphere$_{absorbed}$ − Reflected − Sulface$_{absorbed}$ = 0

$\therefore$ Surface$_{absorbed}$ $= 342 - 67 - 100$

$= 175\ W/m^2$

b) Surface radiation absorbed = Surface radiation emitted − Radiation released to space

$$= \frac{Q}{A} - 30$$

$$= \frac{\sigma 4\pi R^2 T^4}{4\pi R^2} - 30$$

$$= 5.67E{-8}\,(291)^4 - 30$$

$$= 376.59\ W/m^2$$

c) Incoming$_{surface}$ = Outgoing$_{surface}$, x = Back radiation

$175 + x + 30 = 24 + 78 + 406.59 + 30$

$x = 333.59\,W/m^2$

d) Incoming$_{atmosphere}$ = Outgoing$_{atmosphere}$, y = radiation released from atmosphere

$30 + 100 + y = 342$

$y = 212\ W/m^2$

(10) $C_0 = 10\ GtC/yr$

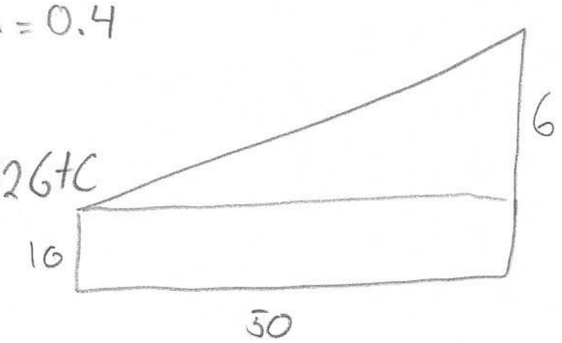
$C_2 = 16\ GtC/yr$

$ppm_0 = 380$

Airborne fraction $= 0.4$

$t = 50\ yrs$

$1\ ppm\ CO_2 = 2.12\ GtC$



$$10\ GtC/yr * 50_{yrs} + \frac{6}{2} \cdot 50 = 650\ GtC$$

$$650 * 0.4 = \frac{260\ GtC}{2.12\ GtC/ppm\ CO_2} = 122.64\ ppm\ CO_2$$

$$122.64 + 380 = 502.64\ ppm_{CO_2}$$

(11) $r = 2 \text{ ppm/yr}$

9 GtC/yr

airborne = 0.38%

$2.12 \cdot 2 = 4.24 \frac{GtC}{yr} = (9 + x) \cdot 0.38$

$11.16 = 9 + x$

$x = 2.16 \ GtC/yr$

(12) $H = 100m$, $V_a = 10$

$1.2 \frac{g}{s}$ SO_2 per MW

$u_H = 4 m/s$

$u_a = 3 m/s$

limit $= 365 \frac{\mu g}{m^3}$

i) $Q = \frac{1.2 g}{s \cdot MW} \times \frac{10^6 \mu g}{g} \times MW = \frac{1.2E6 \cdot MW}{s}$

ii) Surface wind = 3 m/s. Since conditions not given, worst one assumed (B).

Trial 1) : assume $\geq 1 km$, $a = 156$, $c = 108.2$, $d = 1.098$, $f = 2$

$\sigma_y = a x^{0.894}$
$= 156 (1)^{0.894}$
$= 156$

$\sigma_z = c x^d + f$
$= 108.2 (1)^{0.516} + 2$

$= 110.2$

$$C(x,y) = \left[\frac{Q}{\pi \cdot u_H \cdot \sigma_y \cdot \sigma_z} \right] \cdot e^{-y^2/2\sigma_y^2} \cdot e^{-H^2/2\sigma_z^2}$$

$$C(1,0) = \frac{1.2E6\ MW}{\pi \cdot 4 \cdot 156 \cdot 110.2} \cdot e^{-(300)^2/2(110.2)^2}$$

$$\frac{365 \cdot \pi \cdot 4 \cdot 156 \cdot 110.2}{1.2E6 \cdot e^{-(300)^2/2(110.2)^2}} \geq MW, \quad MW \leq 2672.5$$

Trial 2) assume $\leq 1 km$, $a = 156$, $c = 106.6$, $d = 1.149$, $f = 3.3$

$\sigma_y = a x^{0.894}$
$= 156(1)$
$= 156$

$\sigma_z = c x^d + f$
$= 106.6(1) + 3.3$
$= 109.9$

$$MW \leq \frac{365 \cdot \pi \cdot 4 \cdot 156 \cdot 109.9}{1.2E6 \cdot e^{-(300)^2/2(109.9)^2}}, \quad MW \leq 2719.75,$$

$\therefore$ More conservative that max MW is about 2719.75 MW

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$10\,000 \frac{veh}{hr}$

$x = 0.2\ Km$

$1.2 \frac{g}{veh\ Km}\ NO_x$

$2\ m/s$

$\frac{g}{m \cdot s}$, 1) $q = 10\,000 \frac{veh}{hr} \times \frac{1\ hr}{3600\ s} \times \frac{1.2\ g}{km \cdot veh} \times \frac{1\ Km}{1000\ m} = 0.003333333\ g/m \cdot s$

$C(x) = \frac{2q}{\sqrt{2\pi}\,\sigma_z u}$, $\sigma_z = c \cdot x^d + f$, since class A & $\leq 1 Km$, $c = 440.8$, $d = 1.941$, $f = 9.27$

$= 440.8(0.2)^{1.941} + 9.27$

$= 28.65834805\ m$

$C(0.2) = \frac{2(0.0033333)}{\sqrt{2\pi} \cdot 28.6583 \cdot 2} = 0.0000464 01\ g/m^3$

(14) Stack
$1656.2\ g/s \times 10^6\ \mu g/g$

$y = 0$ 16562 00000

$x = 3$

$h = 120\ m$

$d = 1.2\ m$

$V_s = 10\ m/s$

$T = 588\ K$

Atmospheric conditions

$P = 95\ kPa$

$T_a = 25 + 273 = 298$

Overcast

u Wind speed $4.5\ m/s$

$$C(x) = \left[\frac{Q}{\pi u_H \cdot \sigma_y \cdot \sigma_z}\right] e^{-\frac{H^2}{2\sigma_z^2}}$$

I) $\Delta h = \frac{v_s d}{\mu_a}\left[1.5 + \left(2.68 \cdot 10^{-2} \cdot P\left[\frac{T_s - T_a}{T_a}\right] d\right)\right]$

$= \frac{10 \cdot 1.2}{4.5}\left[1.5 + 2.68E{-2} \cdot 95\left[\frac{588 - 298}{298}\right] 1.2\right]$

$= 11.928\ m$

$H = 120 + 11.928$, $H = h + 11.928$, $90 < h < 150$

$= 131.928$

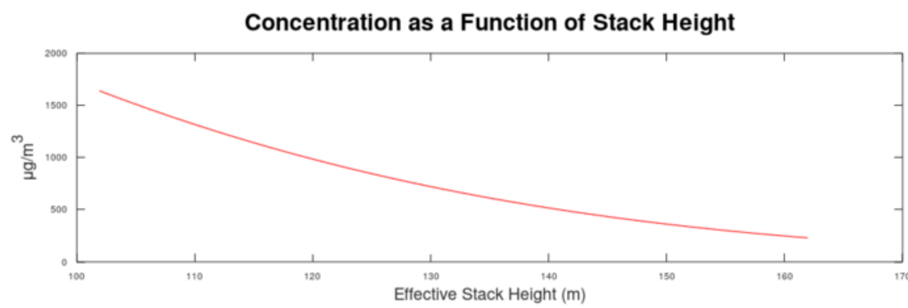
II) Assume class D since overcast, $a = 68$, $c = 44.5$, $d = 0.516$, $f = -13$, $p = 0.25$

$\frac{u_H}{u_a} = \left(\frac{H}{2a}\right)^p$ sigma_y = 68 · 3^0.894

$u_H = 4.5\left(\frac{H}{10}\right)^{0.25}$ Sigma_z = 44.5 · 3^0.516 − 13

Question 14

Using MATLAB, the relationships between effective stack height, distance from centerline, and concentration were plotted (below).



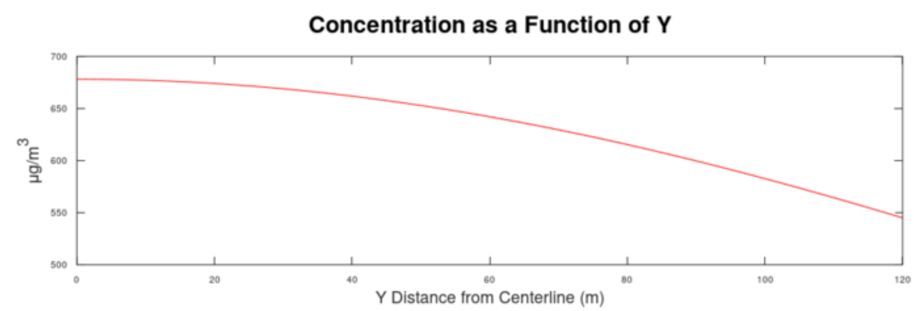


Figure 1: Impacts on Concentration

As can be seen, the concentration decreases as the effective stack height increases. This is also true as the distance from centerline increases. I would estimate that the drop begins to be significant around the 30 m point, as it shifts from barely decreasing before 30 to strongly decreasing after 30.