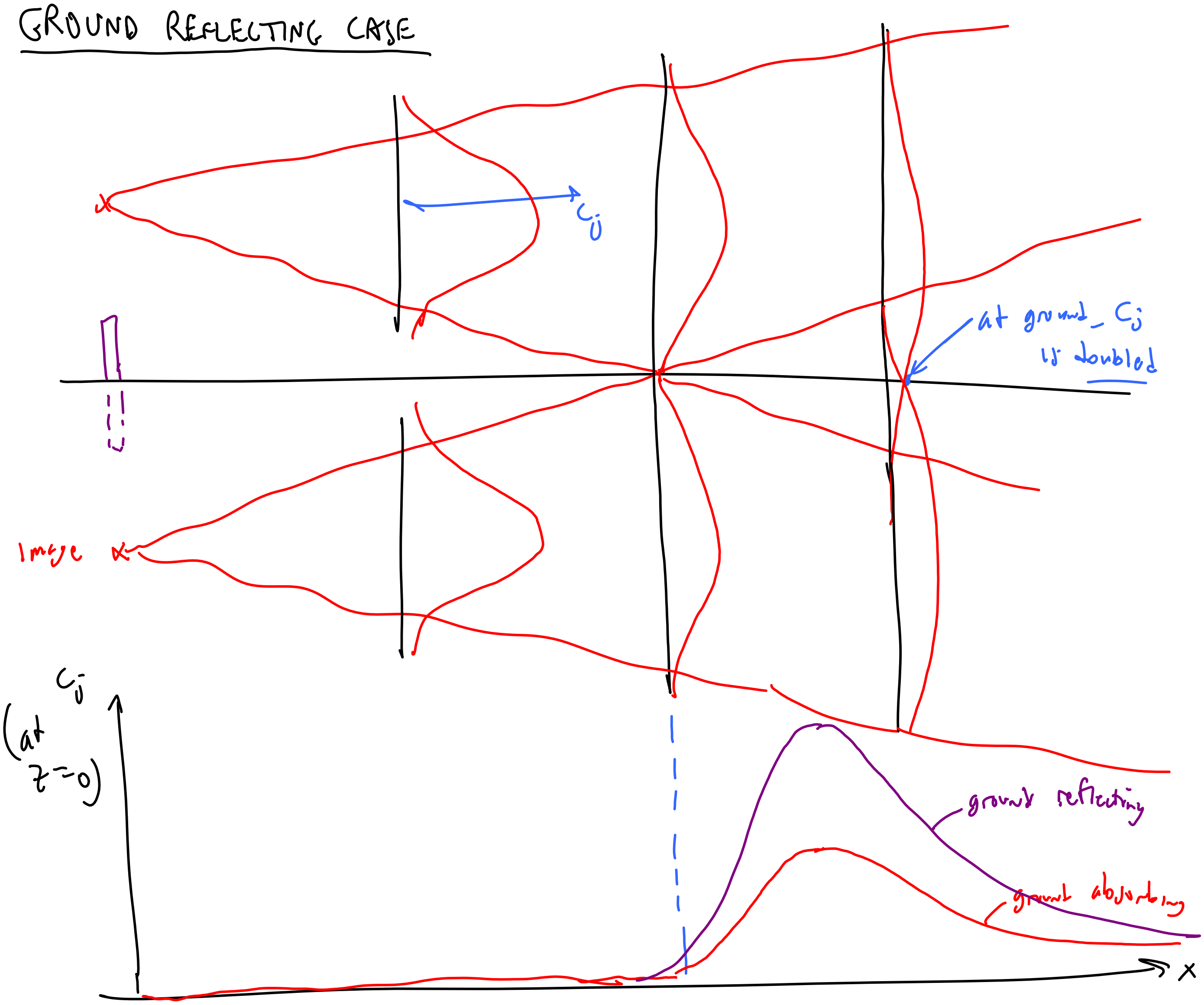
Today, we will:

- Continue discussing the Gaussian plume model – prediction of hazardous area downwind of a plume, what to do about temperature inversions and fumigating plumes

GROUND REFLECTING CASE



Example: Gaussian plume

Given: A buoyant plume emitting air pollution, under the following conditions:

- Stack height = 80 m = h_s
- Buoyant plume rise = 40 m above stack exit = δh } $H = 80 + 40 = 120$ m
- Clear summer day with Sun high in the sky (early afternoon)
- The ground reflects (does not absorb) the air pollutant
- Average wind speed = 5.5 m/s = U
- The stack emits the air pollutant at a rate of 110 g/s = $\dot{m}_{j,s}$

To do: Calculate the downwind location (x) that has the maximum ground concentration. (@ y = 0, @ z = 0)

Solution:

- First, use **Table 20.1** to determine the atmospheric stability class:
  At U = 5.5 m/s in the daytime with strong incoming solar radiation, this is **Class C**.
- Next, use **Table 20.2** to obtain the coefficients for calculation of dispersion coefficients:
  For Class C, we have ***a* = 104, *b* = 0.894, *c* = 61.0, *d* = 0.911,** and ***f* = 0**.
- At a given x location, calculate the dispersion coefficients:
  $\sigma_y = ax^b$, $\sigma_z = cx^d + f$, with x in units of km and σ_y and σ_z in units of m.
- The effective stack height is $H = h_s + \delta h = 80 + 40 = 120$ m.
- Use the reflecting ground Gaussian plume equation at $y = 0$ (centerline) and $z = 0$ (ground) to calculate the maximum ground concentration at various values of x:

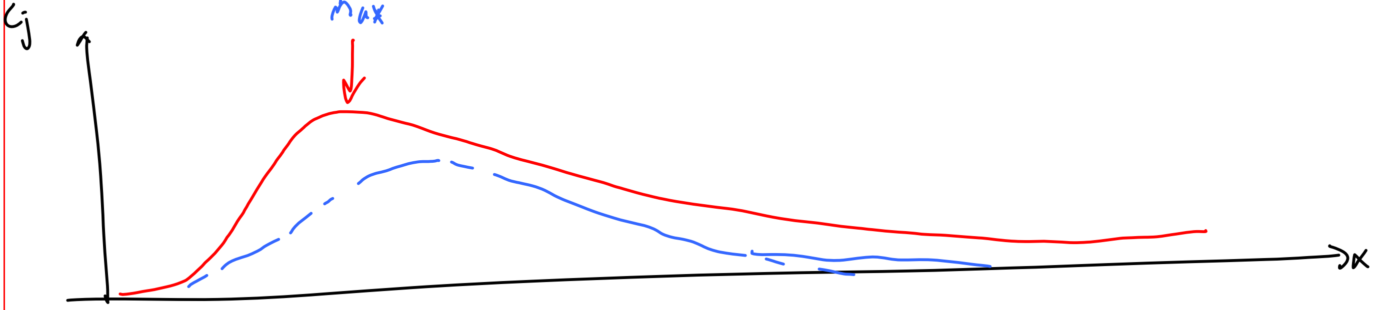
$$c_j = \frac{\dot{m}_{j,s}}{2\pi U \sigma_y \sigma_z}\left[\exp\left\{-\frac{1}{2}\left[\left(\frac{y}{\sigma_y}\right)^2 + \left(\frac{z-H}{\sigma_z}\right)^2\right]\right\} + \exp\left\{-\frac{1}{2}\left[\left(\frac{y}{\sigma_y}\right)^2 + \left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}\right]$$

Table to be filled in during class: Note: U = 5.5 m/s, H = 120 m, and $\dot{m}_{j,s} = 110$ g/s.

x (km)	c_j (μg/m³)
0.4	0.181
0.6	18.7
0.8	82.1
1.0	145
1.2	180
1.4	192
1.6	189
1.8	179

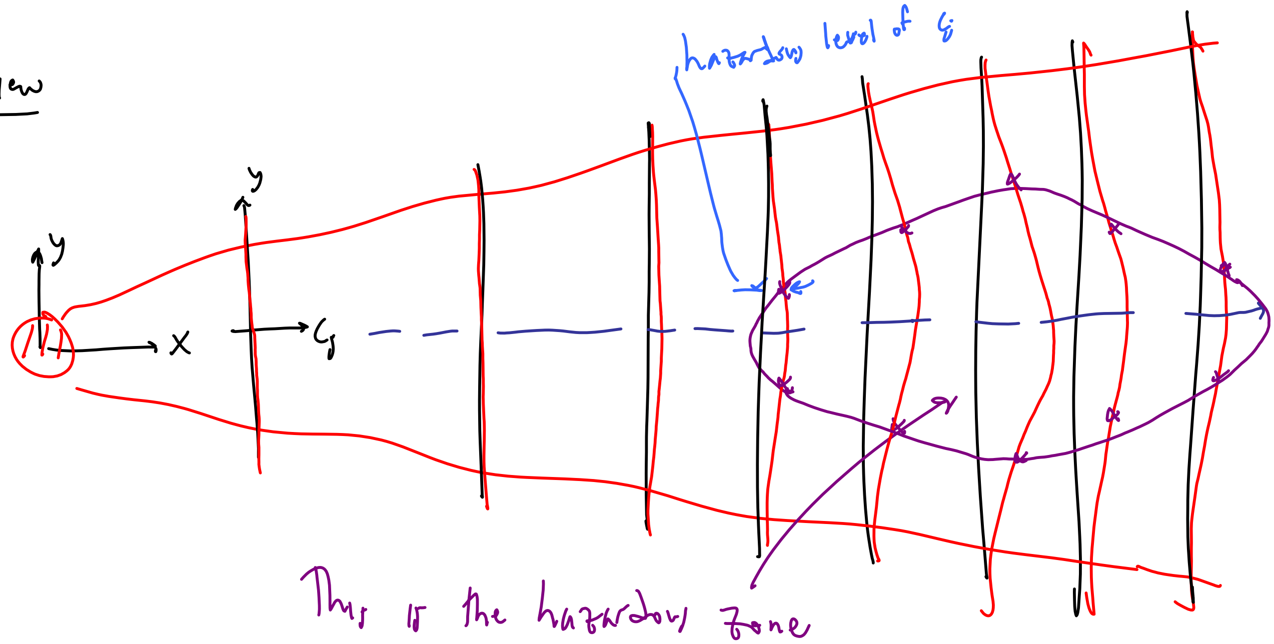
x (km)	c_j (μg/m³)
2.0	166
2.2	153
2.4	139.6
2.6	127.4
2.8	116
3.0	106.5
3.2	98
3.4	89.5

max



Predict what area on the ground downwind of a plume will have concentrations of j that are dangerous

Top view



Temperature Inversion & Absorbing Grounds

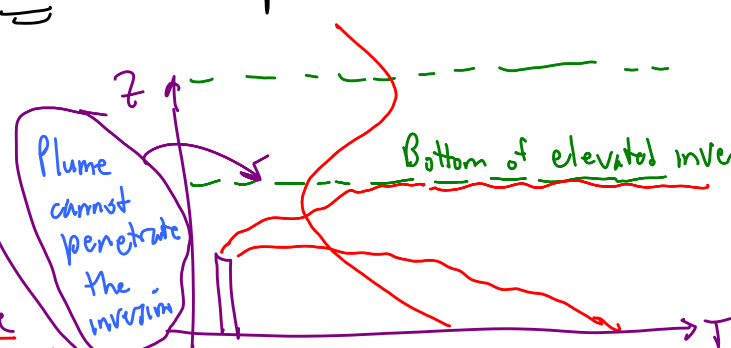
- Use Class F → most stable class if plume is within the inversion

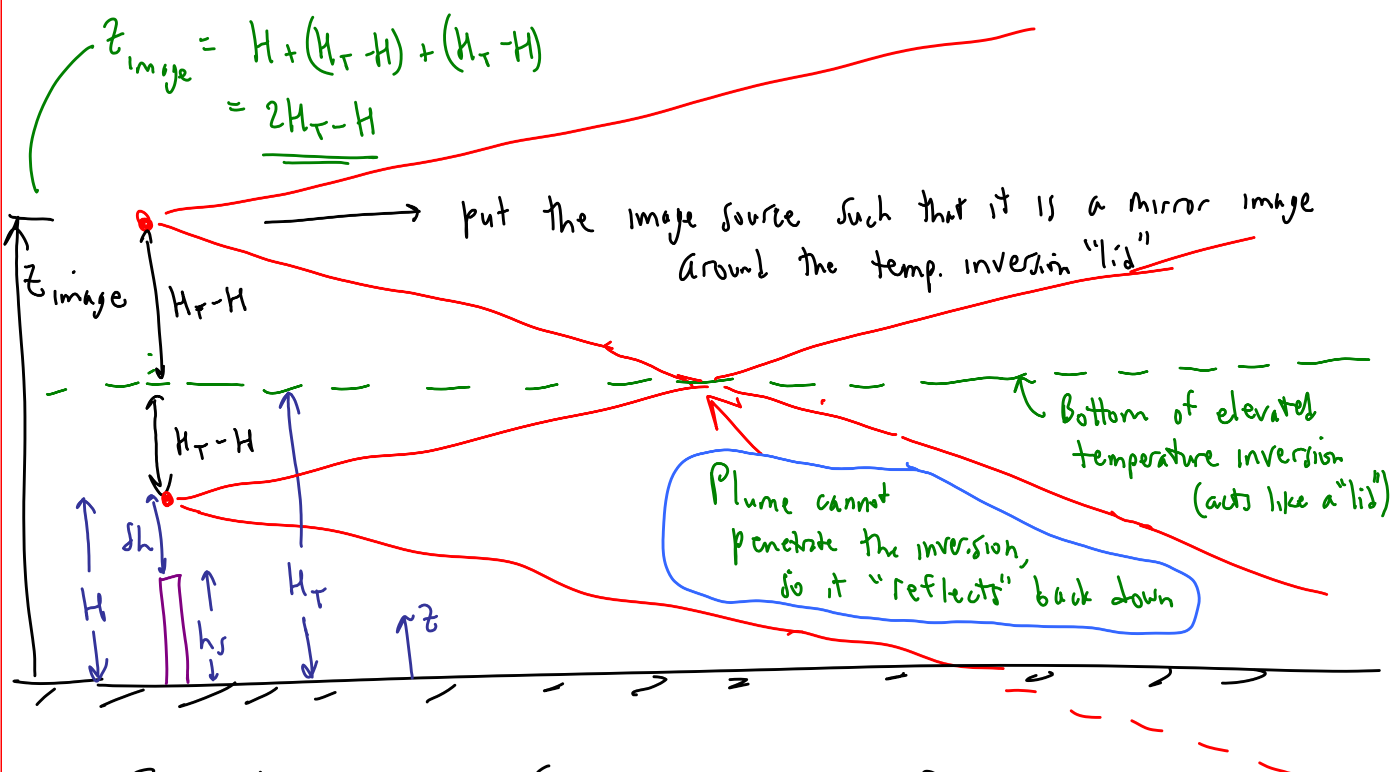
[if elevated temp inversion & if plume is below the elevated inversion this does not apply] — Use appropriate stability class, as previously.

Will add an image above the temp. inversion "lid"

but where?

☆ Consider the case with an elevated temperature inversion





For $h_s = 40$ m, $\delta h = 20$ m, $H_T = 85$ m

Where (@ what z in m) do we place our image source?

$$\boxed{z_{image} = 2H_T - H} = 2(85\text{ m}) - 60\text{ m} = \boxed{110\text{ m}}$$

In the exp. term of the Gaussian → add a source

with →
$$\left(\frac{z - \overbrace{(2H_T - H)}^{z_{image}}}{\sigma_z}\right)^2$$

USE:
$$\boxed{e^{a+b} = e^a e^b}$$

Eq becomes

$$\boxed{C_j = \frac{\dot{m}_{j,s}}{2\pi U \sigma_y \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \cdot \left\{ \exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z - (2H_T - H)}{\sigma_z}\right)^2\right] \right\}}$$

☆ ABSORBING GROUND WITH TEMPERATURE INVERSION