

SKAA3913

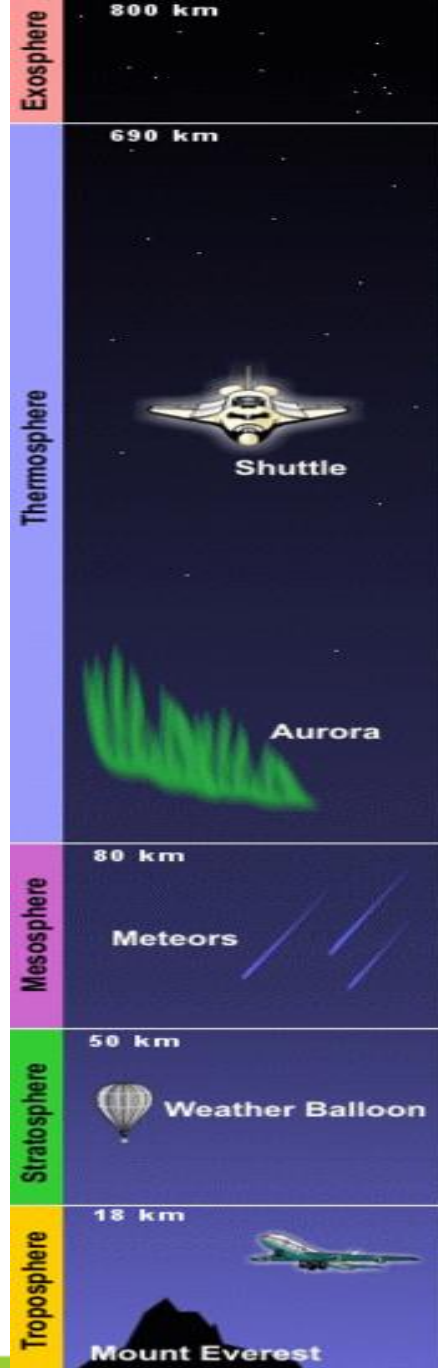
ENVIRONMENTAL MANAGEMENT

AIR POLLUTION



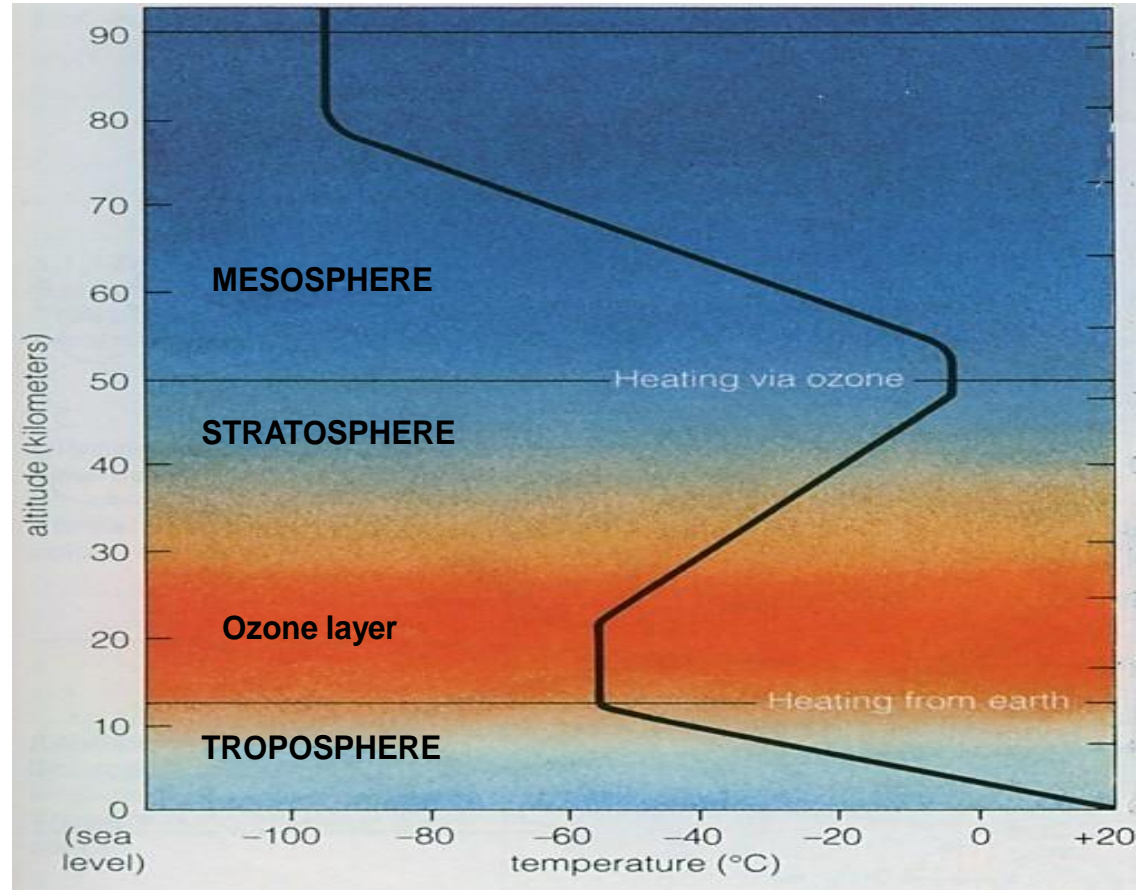
AIR

- ❑ The earth is surrounded by a blanket of air called the atmosphere
- ❑ Earth atmosphere is a mixture of gases that forms a layer about 250 miles thick around the earth
- ❑ Various gases that act as a protective shield for the earth and allow life to exist



AIR (CONT')

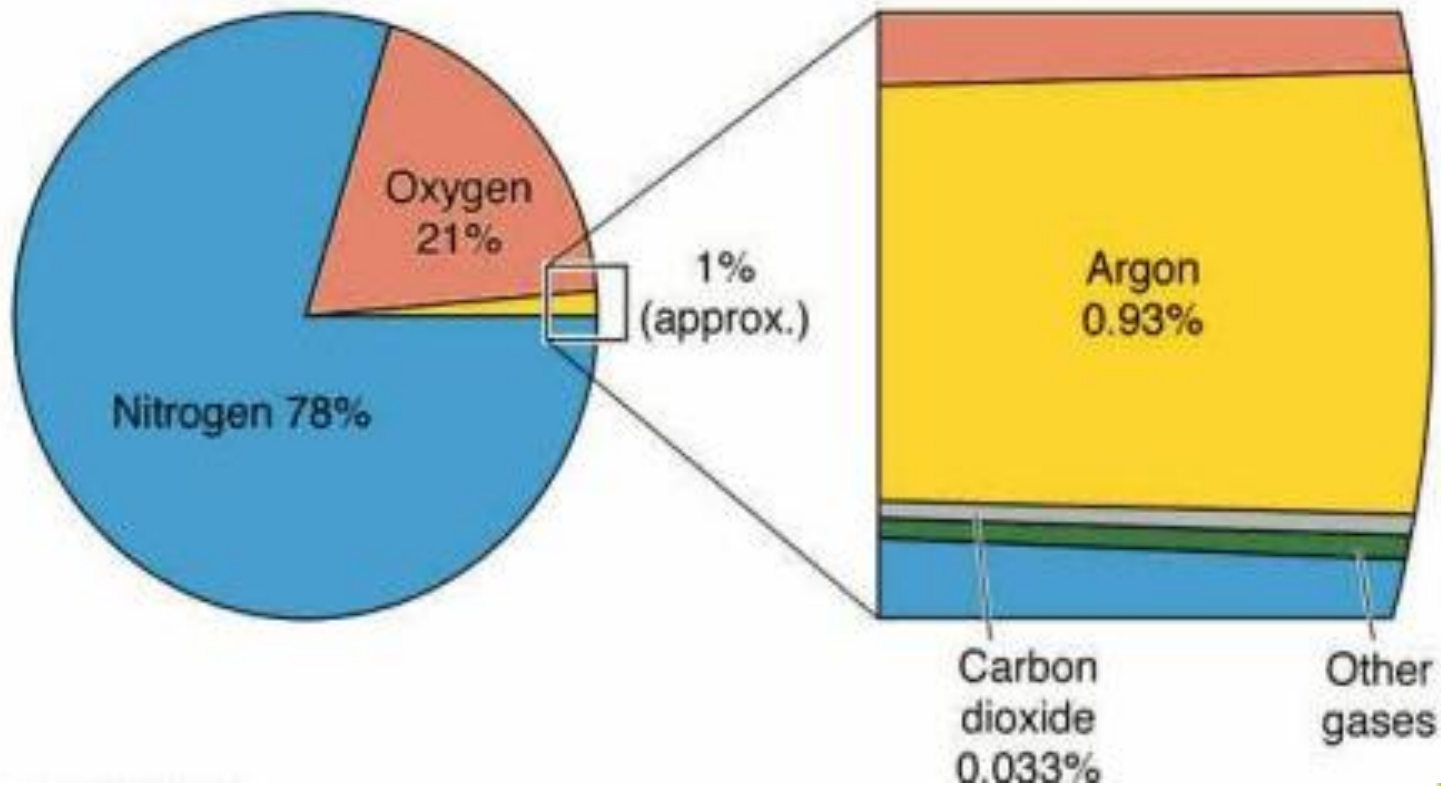
- ✚ Ozone layer is primarily responsible for absorbing the ultraviolet radiation from the Sun.
- ✚ When oxygen is produced in the atmosphere an ozone layer form and prevent an intense flux of ultraviolet radiation from reaching the surface, where it is quite hazardous to the evolution of life.



AIR (CONT')

☒ Gases in the atmosphere

- ☒ The oxygen in the earth's atmosphere almost all produced by plants



AIR (CONT')

❏ The importance

❏ In average human needs $><22.7\text{kg}$ of air daily to supply enough O_2 for body (Zaini Ujang,2000)

Activity	Liter/min	Liter/day	Kg/day
Resting	7.4	10600	12
Light Work	28	40400	45
Heavy Work	43	62000	69



AIR (CONT')

✦ The necessity

Needs	Daily amount	Max deprivation
Food	1.36kg	5 weeks
Water	2.26kg	5 days
Air	22.67kg	5 minutes



AIR POLLUTION

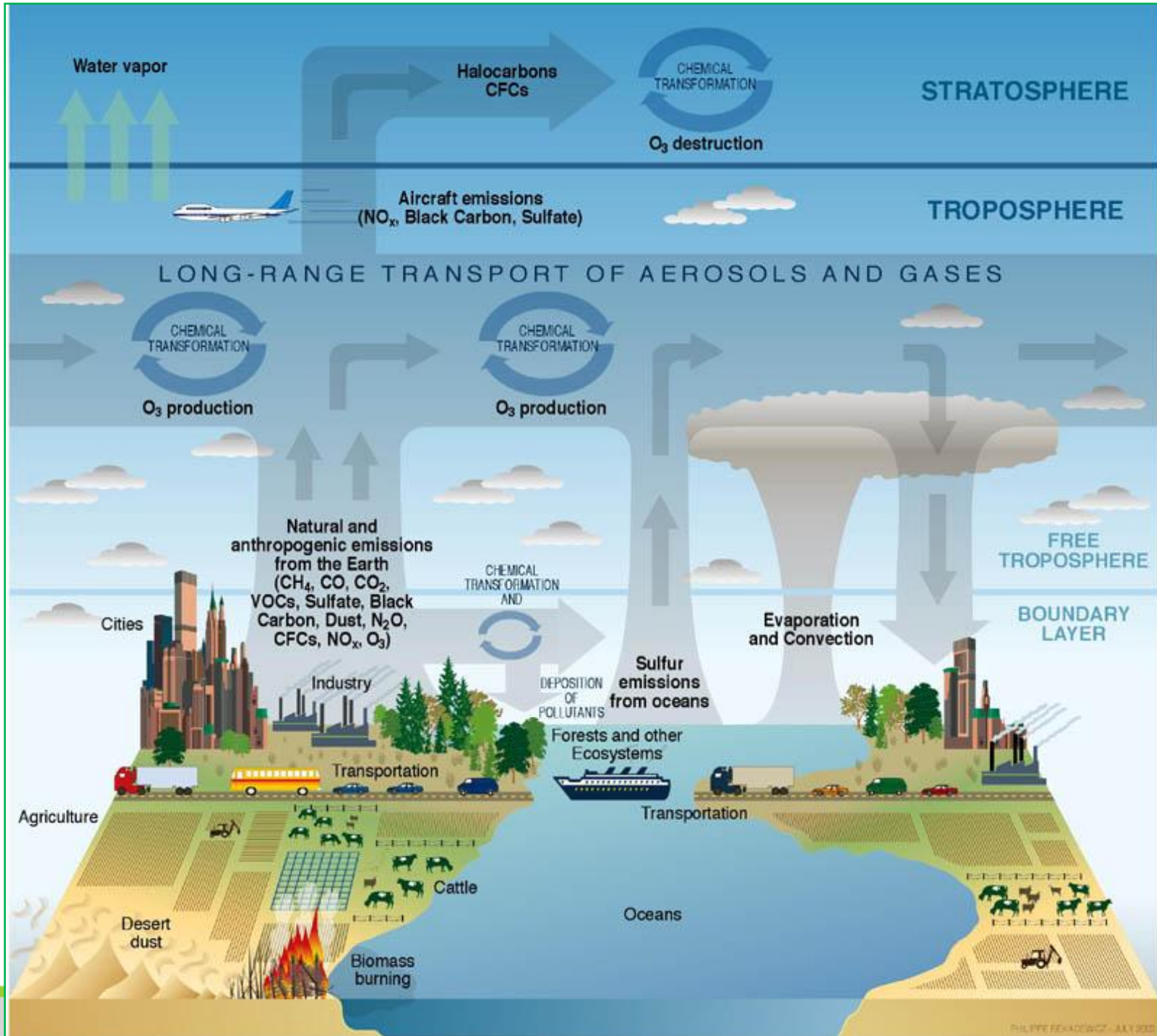
Definition:

“ Air pollution is the presence in the atmosphere of substances put, there by the acts of man, in **concentrations sufficient to interfere** with health, comfort, safety, and full use & enjoyment of property “



SHORT VIDEO ON AIR POLLUTION





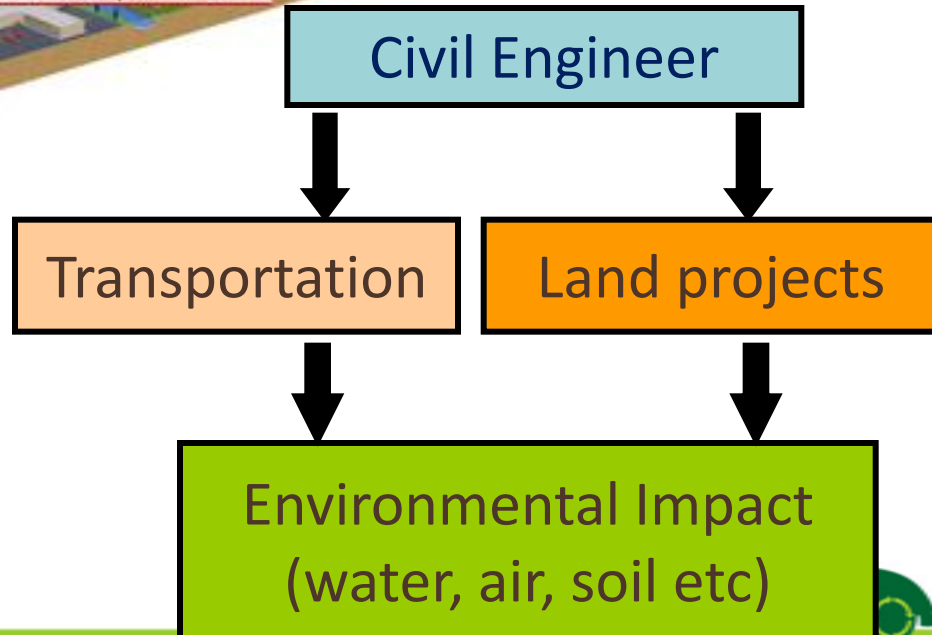
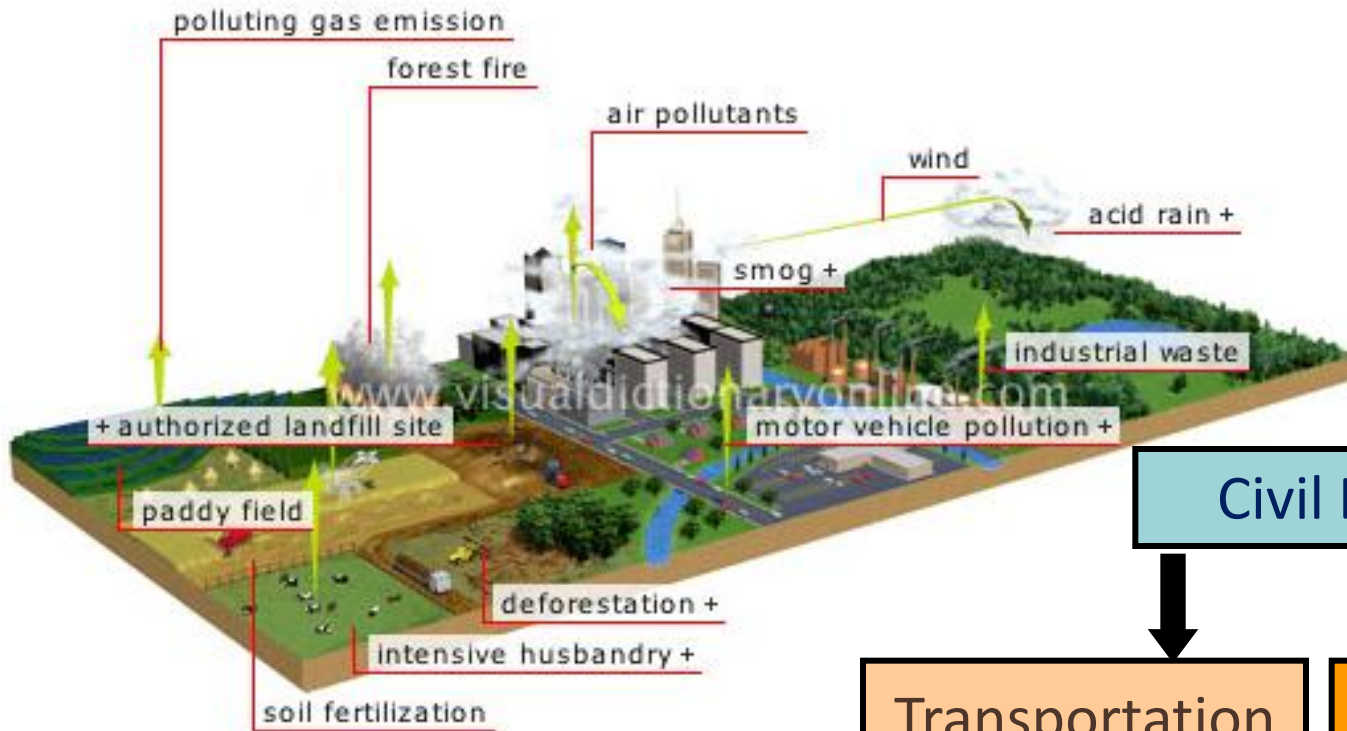
AIR POLLUTION (CONT')

- ❏ The diagram in previous slide explained the transport of aerosols and gases in troposphere layer.
- ❏ Emissions from natural sources and human activities enter the atmosphere at the surface and are transported to other geographical locations and often higher altitudes.
- ❏ Some emissions undergo chemical transformation or removal while in the atmosphere or interact with cloud formation and precipitation.
- ❏ Some natural events and human activities that change atmospheric composition also change the Earth's radioactive (energy) balance.



AIR POLLUTION (CONT')

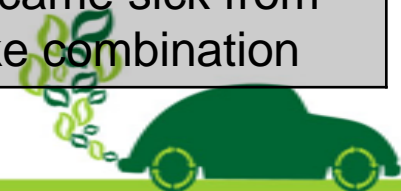
❏ Civil engineer and air pollution knowledge



AIR POLLUTION : IN WORLD

Major air pollution incidents history in the world:

Year	Place	Tragedies
1873-1974 , Winter	London	The fog lasted from November to February. In the week following the worst of it, deaths rose 75%
1930, December 2-5	Meuse Valley, Belgium	In three days, 60 people had died caused by pollutants trapped beneath the dense fog clouds. Thirty different chemicals were identified as causing the illness.
1948, October 30-31	Donora,USA	Toxic gases from industrial and domestic furnaces to float above the coal mining community of Donora. 20 people died and another 6,000 became sick from the fog and smoke combination



AIR POLLUTION : IN WORLD

☒ The Donora Fluoride Fog of 1948

Taken at noon on October 29, 1948



Donora's mills belch forth
smoke and other substances



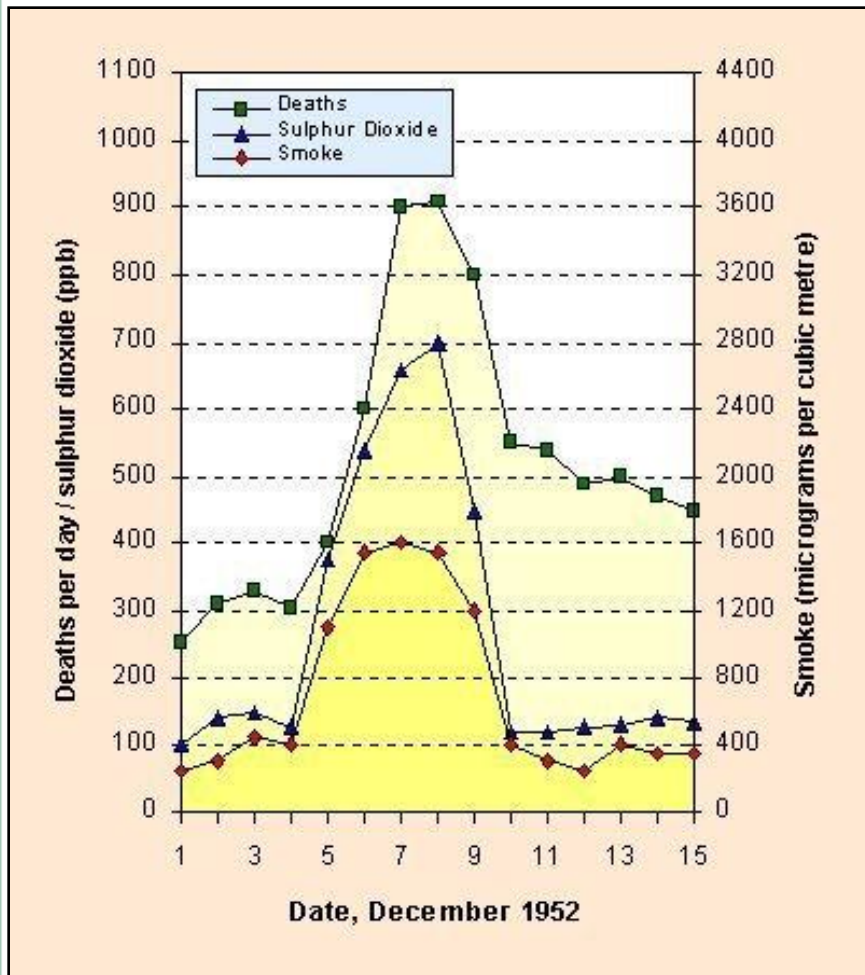
AIR POLLUTION : IN WORLD

Major air pollution incidents history in the world:

Year	Place	Tragedies
1952, December (lasted for 4 days)	London	12,000 people died from the so-called killer fogs of London, produced by the condensation of water on the daily 2,000 tons of sulfur dioxide and pollutants produced by coal -burning industrial furnaces and home heating systems in the city..The Great Smog
1966, November 27	New York,USA	About 400 people perished because of respiratory failure and heart attacks caused by extreme smog conditions.
1984,	Bhopal, India	A toxic cloud drifted over the city from the Union Carbide pesticide plant. This gas leak managed to kill 20,000 people and permanently injured a whopping 120,000 people

AIR POLLUTION : IN WORLD

☒ The Great Smog London



AIR POLLUTION : IN WORLD

The Bhopal gas tragedy



1984

2009



HAUNTING IMAGES OF THOSE WHO RELIVE THE TRAGEDY DAILY: Rupesh, Adil, Shanu - Some survivors of the Bhopal gas tragedy

International Campaign for Justice in Bhopal

- WHAT HAPPENED IN BHOPAL? ▶
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- ABOUT ICJB ▶
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THE FIGHT CONTINUES
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AIR POLLUTION : IN WORLD

- ❏ Urban air pollution – of which a significant proportion is generated by vehicles, as well as industry and energy production – is estimated to kill some 1.2 million people annually (Laube, 2002).
- ❏ Today, many developing world cities face very severe levels of urban air pollution – higher than developed world counterparts (Health Effect Institute, 2004; Peden et al., 2004).



AIR POLLUTION : IN MALAYSIA

30-09-2015 (Wednesday) - 06:00AM - 11:00AM / Department of Environment Malaysia

+ Choose different date and time.

NEGERI / STATE	KAWASAN/AREA	MASA/TIME 06:00AM	MASA/TIME 07:00AM	MASA/TIME 08:00AM	MASA/TIME 09:00AM
Johor	Kota Tinggi	108*	107*	107*	106*
Johor	Larkin Lama	125*	123*	122*	120*
Johor	Muar	121*	120*	120*	119*
Johor	Pasir Gudang	133*	132*	132*	131*
Kedah	Alor Setar	36*	35*	36*	38*
Kedah	Bakar Arang, Sg. Petani	53*	53*	52*	52*
Kedah	Langkawi	31*	30*	30*	30*
Kelantan	SMK Tanjung Chat, Kota Bharu	48*	49*	50*	51*
Kelantan	Tanah Merah	35*	36*	37*	38*
Melaka	Bandaraya Melaka	144*	144*	142*	141*
Melaka	Bukit Rambai	154*	153*	152*	150*
Negeri Sembilan	Nilai	112*	114*	115*	115*
Negeri Sembilan	Port Dickson	140*	141*	141*	142*
Negeri Sembilan	Seremban	112*	115*	116*	117*
Pahang	Balok Baru, Kuantan	136*	135*	135*	135*
Pahang	Indera Mahkota, Kuantan	104*	104*	105*	105*
Pahang	Jerantut	99*	100*	101*	102*
Perak	Jalan Tasek, Ipoh	55*	56*	56*	56*
Perak	Kg. Air Putih, Taiping	59*	60*	60*	61*
Perak	S K Jalan Pegoh, Ipoh	58*	59*	60*	61*
Perak	Seri Manjung	70*	71*	71*	72*
Perak	Tanjung Malim	66*	63*	61*	59*
Perlis	Kangar	26*	27*	27*	27*

MENU

- Latest API Readings
- Geolocation Map
- API Table [Hourly]

- Announcement
- Advice During Haze
- Learn more about API
- Frequently Asked Questions

GENERAL INFORMATION

- Remote Sensing Agency
- Hotspot: (NOAA18)
- Fire Danger Rating System
- Meteorological Department
- Ministry of Health

Disclaimer
Please be informed that the Department of Environment's (DOE) official application for Air Pollutant Index (API) is APIMS with URL <http://apims.doe.gov.my>. The DOE is not responsible for any misleading information gathered from other unreliable websites.

Best viewed using Mozilla Firefox, Google Chrome and Safari with resolution 1280x768 pixels and above.

AIR POLLUTION : IN MALAYSIA

Minivol Tactical Air Sampler
measure PM10 / PM2.5



GrayWolf Toxic Gas Sensors :
Ozone (O_3), Ammonia (NH_3),
Sulfur Dioxide (SO_2), Nitrogen
Dioxide (NO_2), Carbon
Monoxide (CO), Hydrogen
Sulfide (H_2S), Nitric Oxide (NO),
temperature



Air pollution : Sources in Malaysia

❏ Air Pollution sources in Malaysia:

1. **Mobile sources:** Vehicle



AIR POLLUTION : SOURCES IN MALAYSIA

Pencemaran udara semakin membimbangkan

Sinaran matahari 2



Ganggu sistem pernafasan, halang proses fotosintesis

✚ Typical Engine Combustion:

Fuel + Air => Hydrocarbons + Nitrogen Oxides
+ Carbon Dioxide + Carbon Monoxide + water



AIR POLLUTION : SOURCES IN MALAYSIA

❏ Air Pollution sources in Malaysia:

2. **Stationary sources:** Industries, power plants, agro-industry

Power plant site in Perlis



Power plant site in Manjung Perak



AIR POLLUTION : SOURCES IN MALAYSIA

■ Air Pollution sources in Malaysia:

3. **Other sources:** Open burning of agricultural, construction waste and domestic waste

Pembakaran terbuka tak kira masa

Jiran tidak prihatin mencemarkan udara, wujud kurang selesa penduduk



dedahkan penduduk di situ dengan risiko kebakaran. Malah, penduduk ditemui turut mendakwa pernah melihat salah seorang jirannya yang membakar sampah sarap sehingga tanpa disedari mengancam nyawa apabila terdedah kepada risiko kebakaran.

"Pada satu petang ketika sedang berehat di balkoni rumah, tiba-tiba saya terasa panas dan sebaik menoleh ke belakang, saya terkejut apabila melihat api sedang menjilat naik ke atas sebatang pokok nangka di depan rumah jiran.

"Sebaik saja mendengar jeritan saya, dia kelim kabut membawa air dan cuba memadamkan api yang semakin menjilat ke arah kabel elektrik. Mujurlah api sempat dipadamkan tetapi bayangkan jika ia membakar kabel elektrik yang menghala ke rumah penduduk.

"Mereka mungkin tidak sedar perbuatan membakar secara terbuka terutama di musim panas sekarang hanya mendedahkan

HALINA MOHD NOOR | BERITA HARIAN

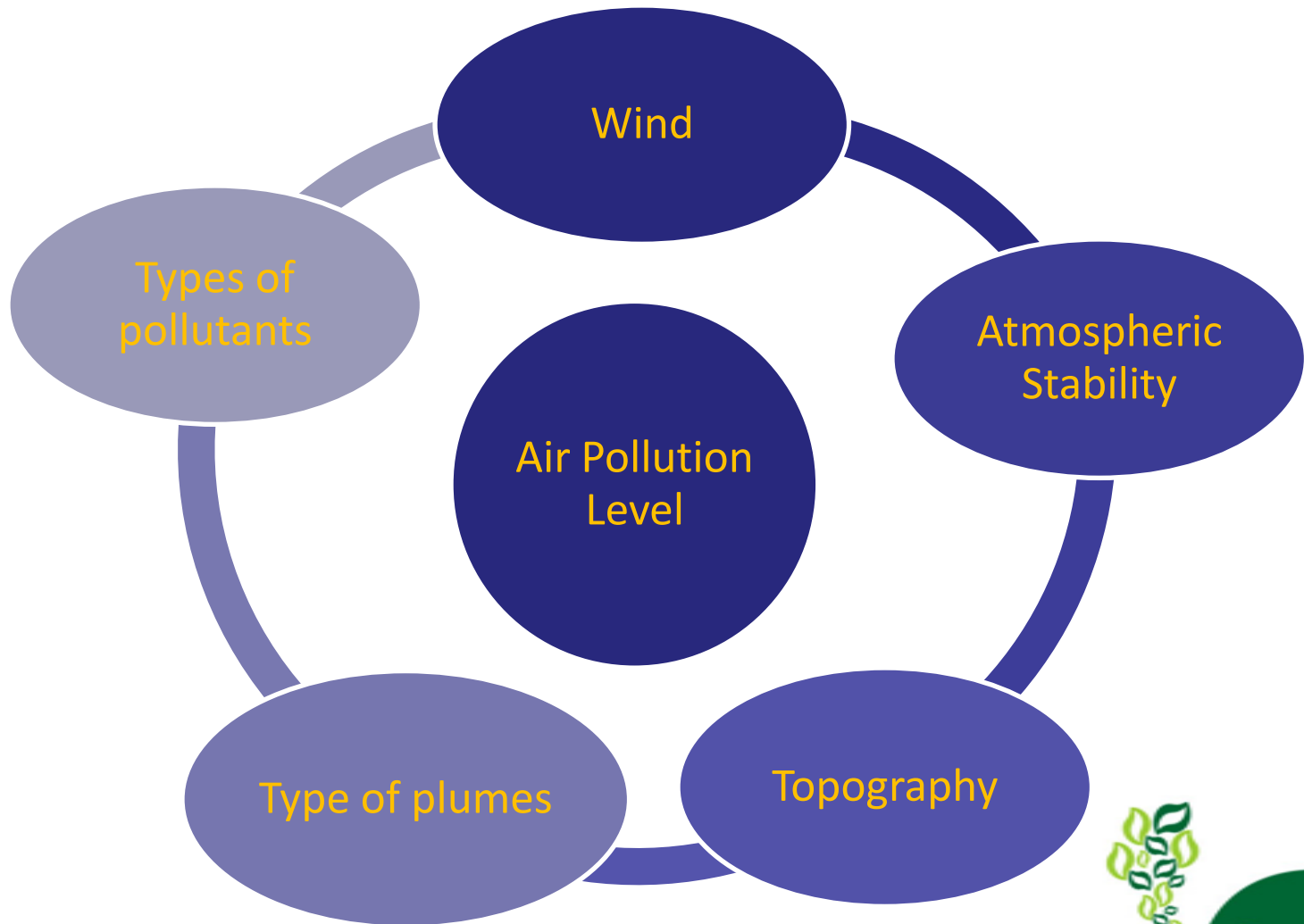
PEMBAKARAN terbuka di depan rumah di Selayang Indah.



AIR POLLUTION : SOURCES IN MALAYSIA



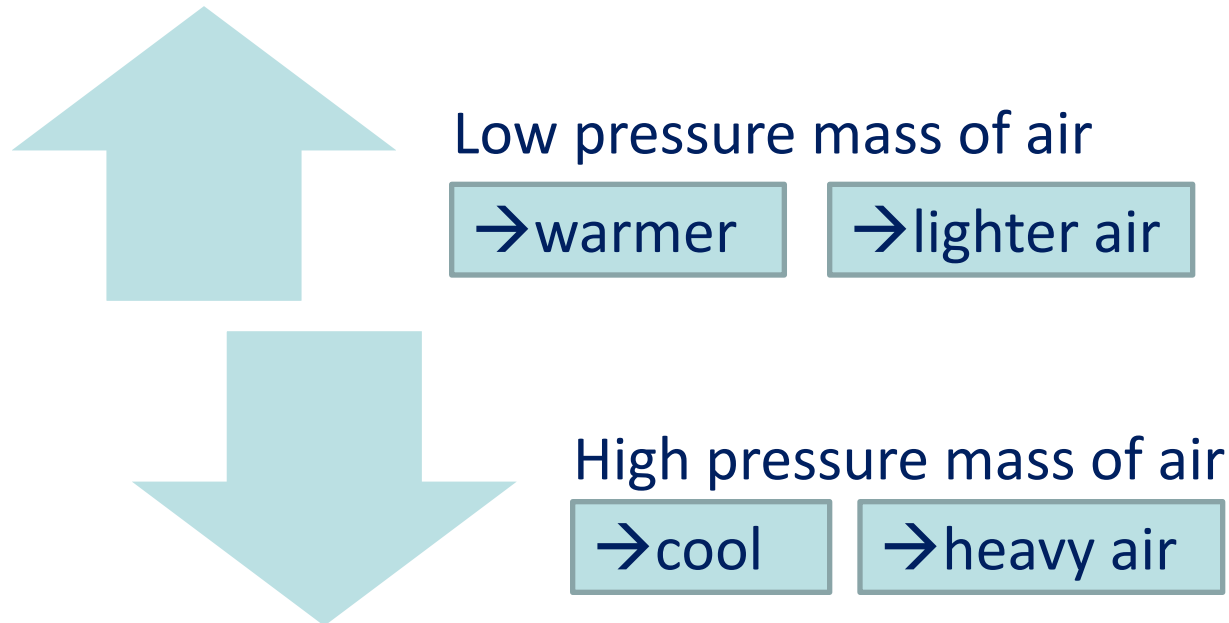
FACTORS AFFECTING AIR POLLUTION LEVEL



FACTORS AFFECTING AIR POLLUTION

LEVEL: WIND

- ❑ Wind is caused by differences in pressure in the atmosphere where the weight of the atmosphere at a given point.
- ❑ The height and temperature of a column of air determines the atmospheric weight.

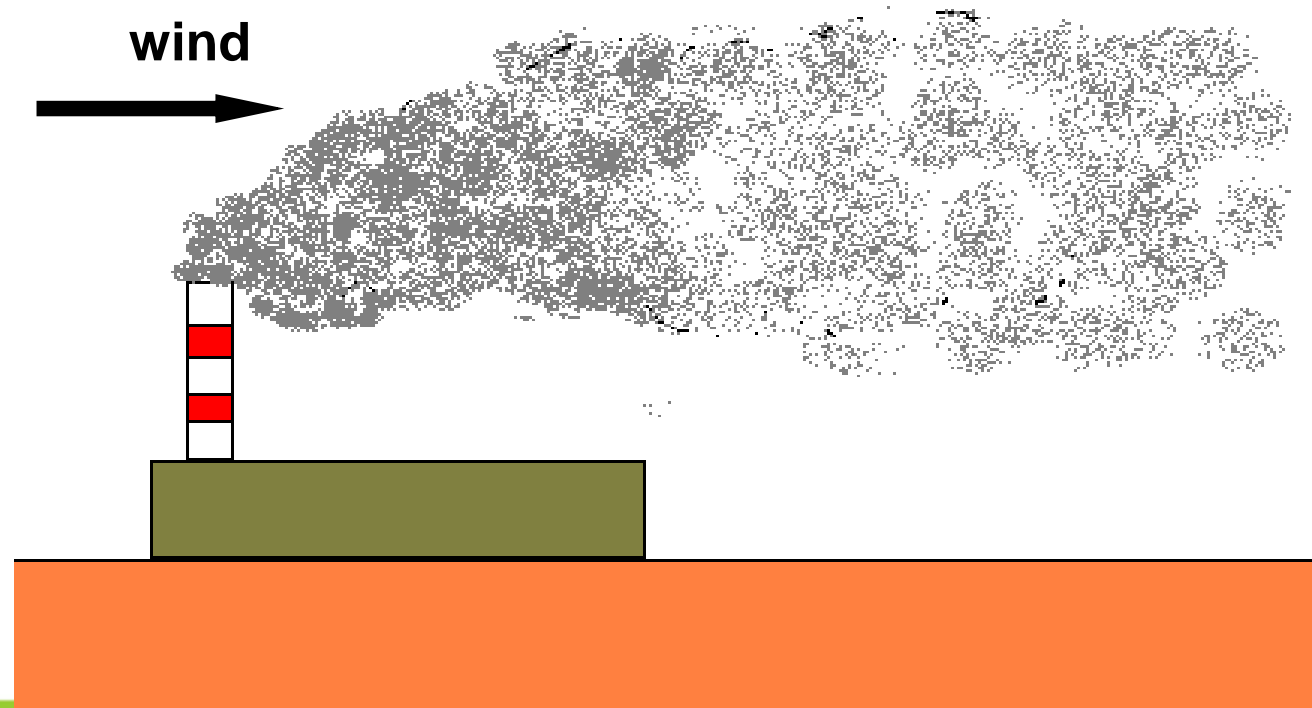


FACTORS AFFECTING AIR POLLUTION

LEVEL: WIND

- Horizontal dispersion of air pollutants depends upon wind speed and direction
- Concentration of pollutants decreases with increasing wind speed

The higher the wind speed → the lower the pollutant concentration.



FACTORS AFFECTING AIR POLLUTION

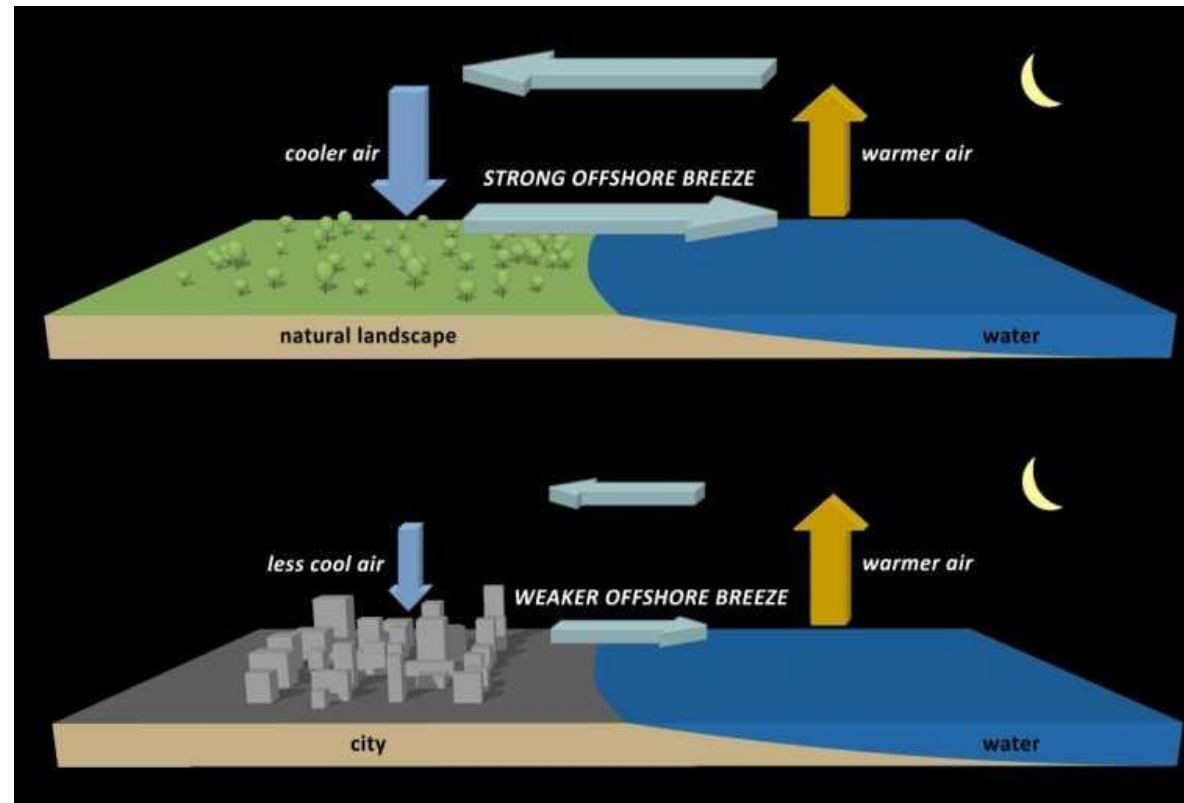
LEVEL: WIND

▣ Buildings in cities can also obstruct wind flow thus further aggravating air pollution problems.

○ City warmer than natural surfaces

○ So, overnight temperature in the city often similar to nearby offshore area

○ These weakens summertime breezes and enables air pollution to build up.



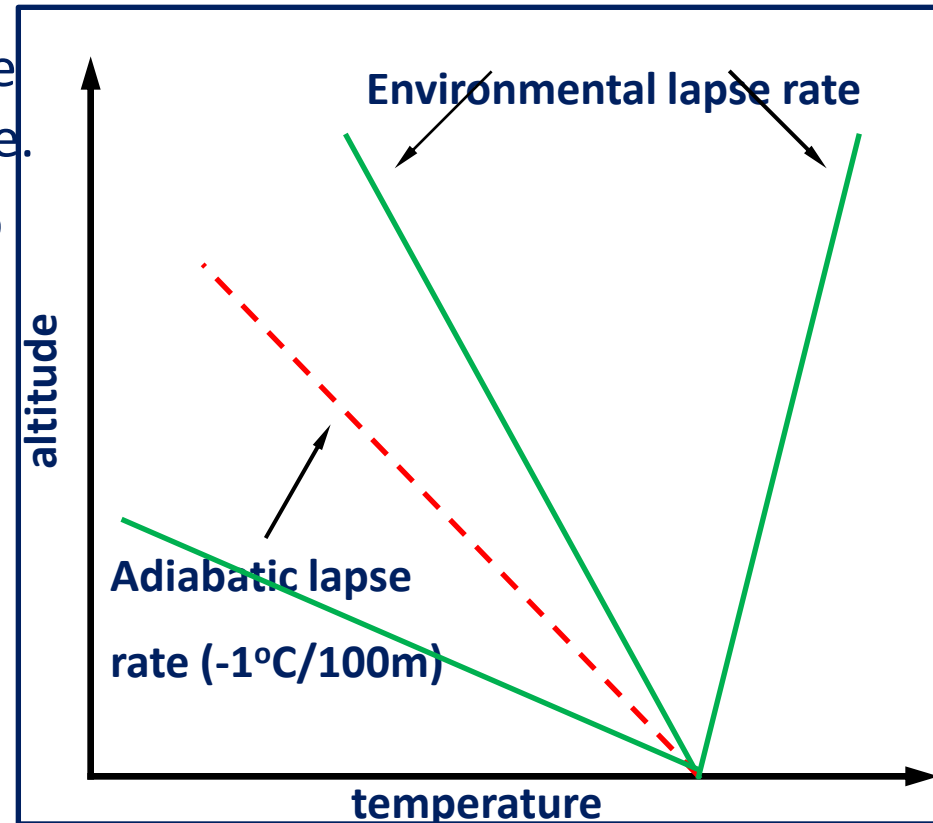
FACTORS AFFECTING AIR POLLUTION

LEVEL: **ATMOSPHERIC STABILITY**

- ❑ Atmospheric stability refers to the vertical motion of the atmosphere.
- ❑ Its depends upon the relationship between air temperature and height / altitude that occurs at a particular time and place
- ❑ Degree of stability is measure of the ability of the atmosphere to disperse/distribute pollutants.

Environmental lapse

- Rate at which the air surrounding a parcel changes temperature.
- So changing based on temperature and measure the stability condition

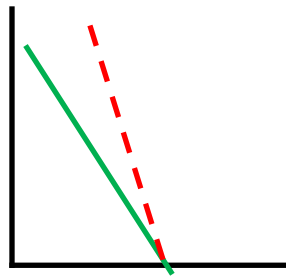


Adiabatic lapse

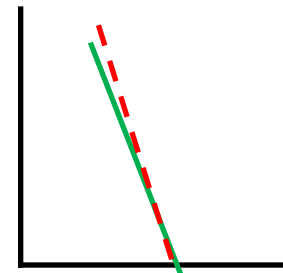
- Rate at which a parcel of air changes temperature with height
- Theoretically measured as every 100m raise in height level temperature decrease **1°C**

The condition:

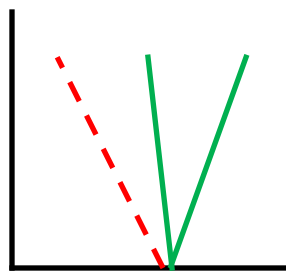
- ❏ To determine whether or not a parcel of air will rise or sink in the atmosphere, one must compare the parcels **temperature** with that of the environment at some **altitude**



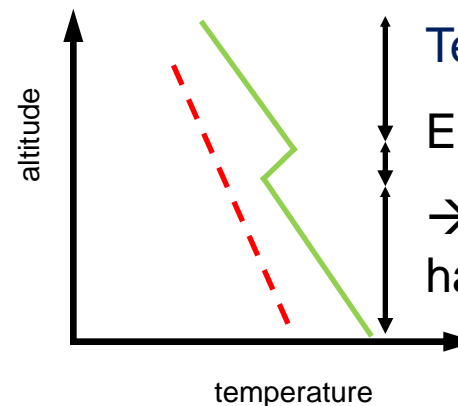
Unstable $ELR < ALR$
→ air parcel cooler than surrounding environment so will rise



Neutral $ELR = ALR$
→ Air parcel equal to surrounding environment so will remain



Stable $ELR > ALR$
→ air parcel warmer than surrounding environment so will sink back

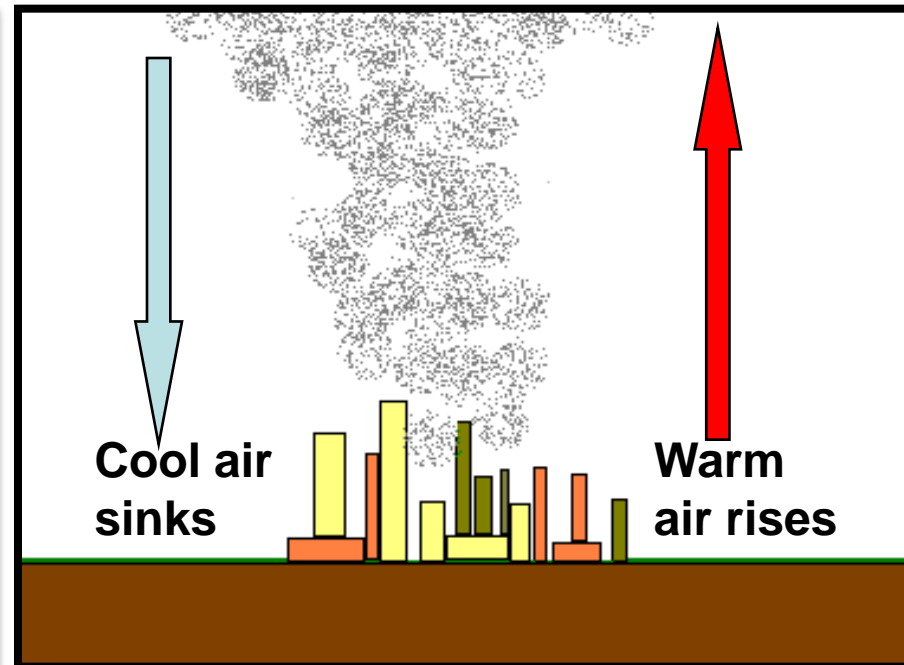
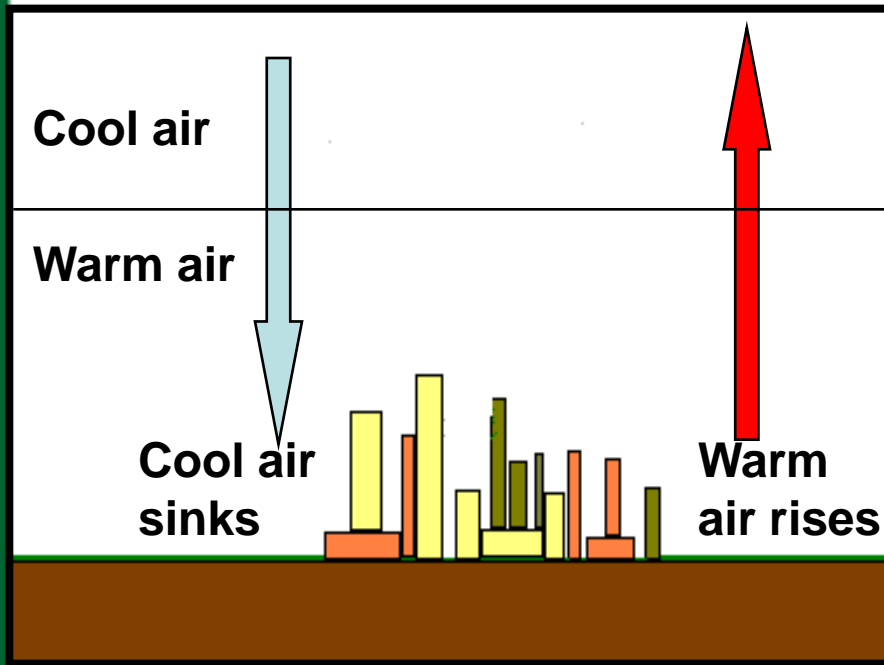


Temperature Inversion
 $ELR \gg ALR$
→ when lapse rate have large gap.

— Environmental lapse rate
- - - Adiabatic lapse rate



FACTORS AFFECTING AIR POLLUTION LEVEL: ATMOSPHERIC STABILITY



❑ Unstable atmosphere

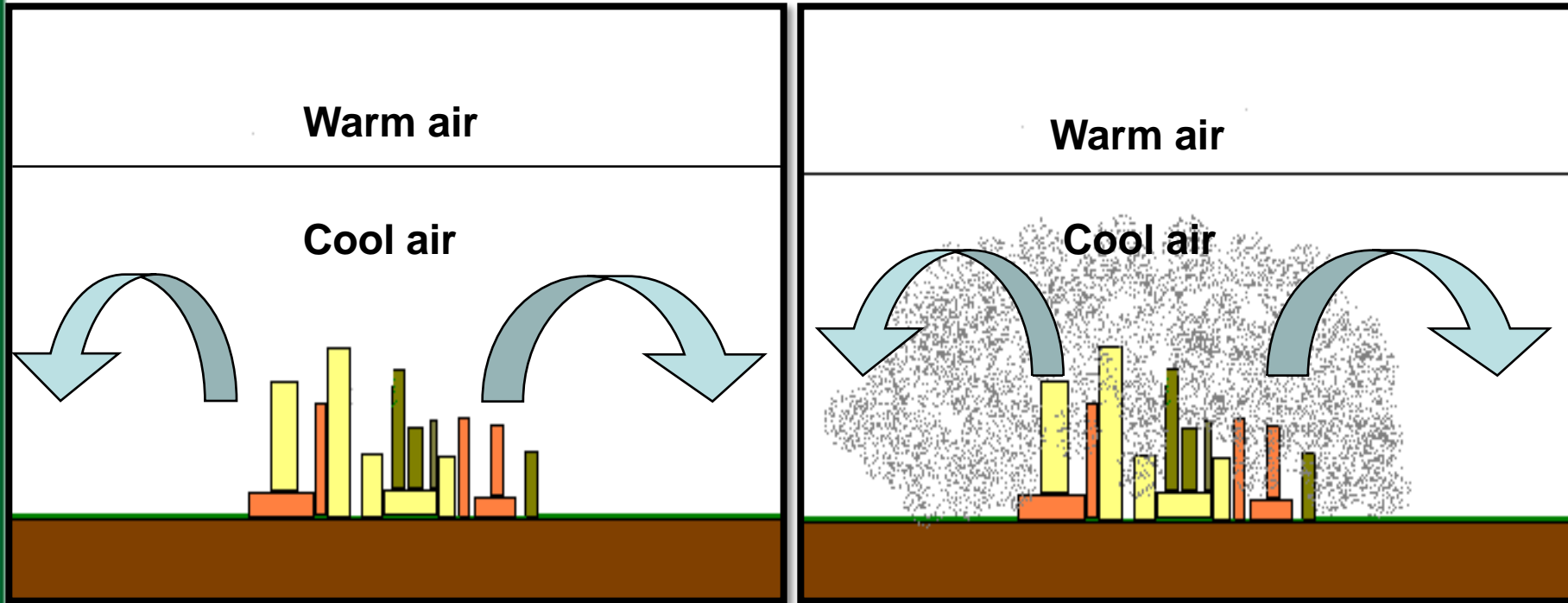
❑ Air masses move naturally in a vertical direction and carry pollutants upward, away from the ground

❑ Usually during noon



FACTORS AFFECTING AIR POLLUTION

LEVEL: **ATMOSPHERIC STABILITY**



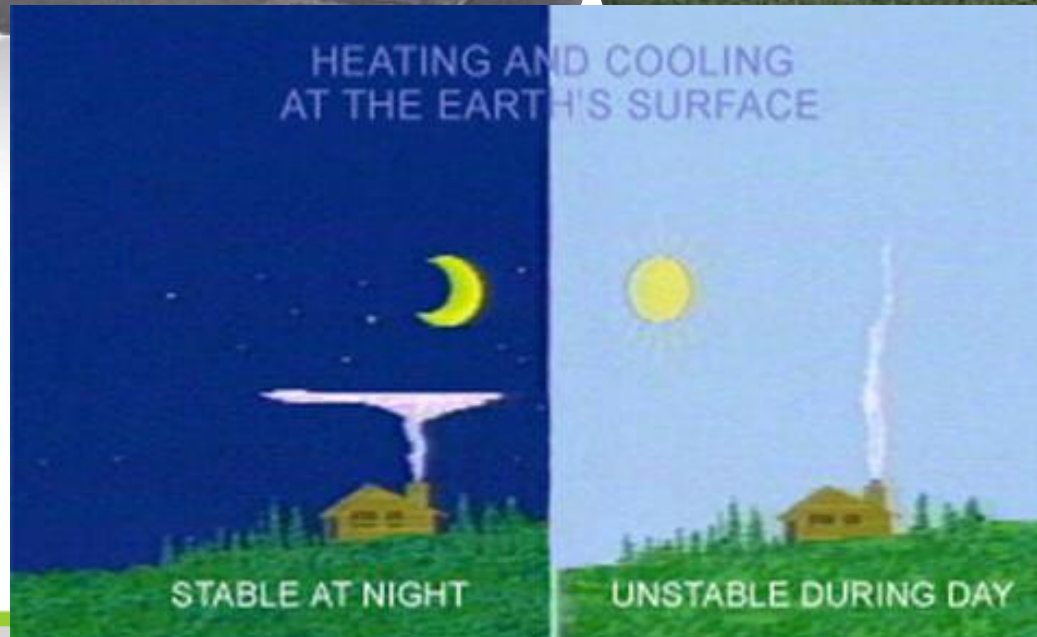
☒ Stable atmosphere

☒ Little or no vertical movement of air masses. As a result, there is no mixing of air pollutants in the vertical direction, and pollutants tend to accumulate near the ground.

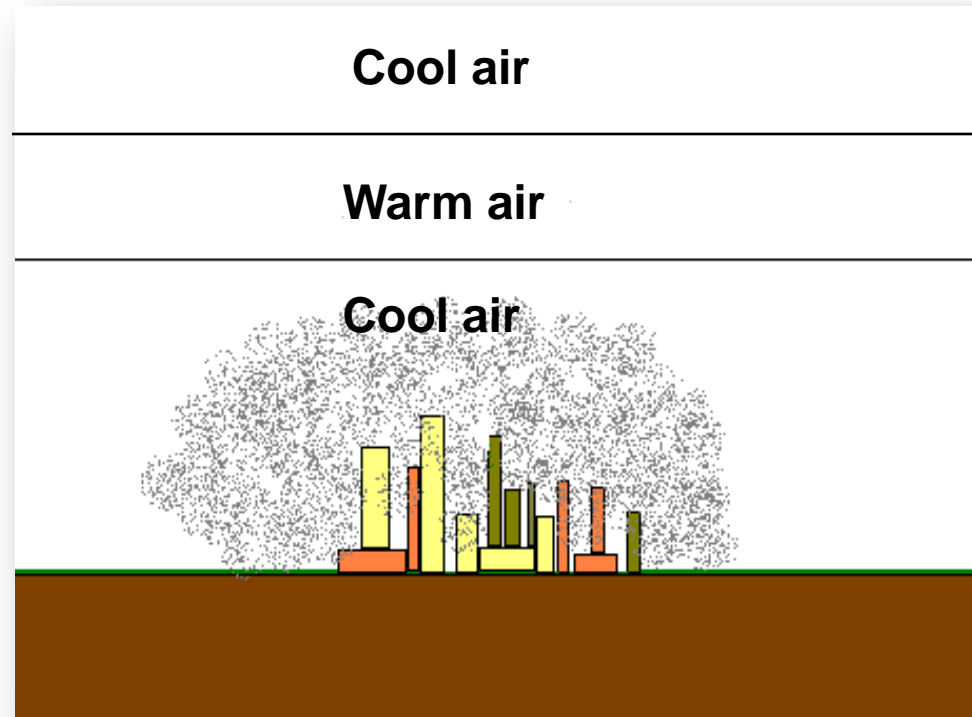
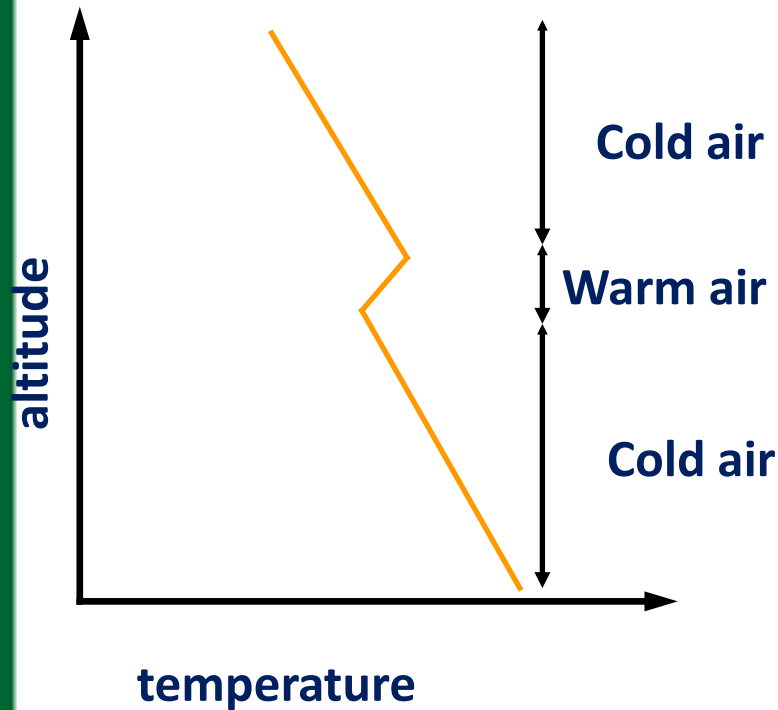
☒ Usually during early morning / late evening

FACTORS AFFECTING AIR POLLUTION

LEVEL: **ATMOSPHERIC STABILITY**



FACTORS AFFECTING AIR POLLUTION LEVEL: ATMOSPHERIC STABILITY



- ❑ **Temperature inversion** is when negative lapse rate occurs and warmer air blankets colder air
- ❑ Inversion layer in the atmosphere characterized by an increase in temperature with an increase in height

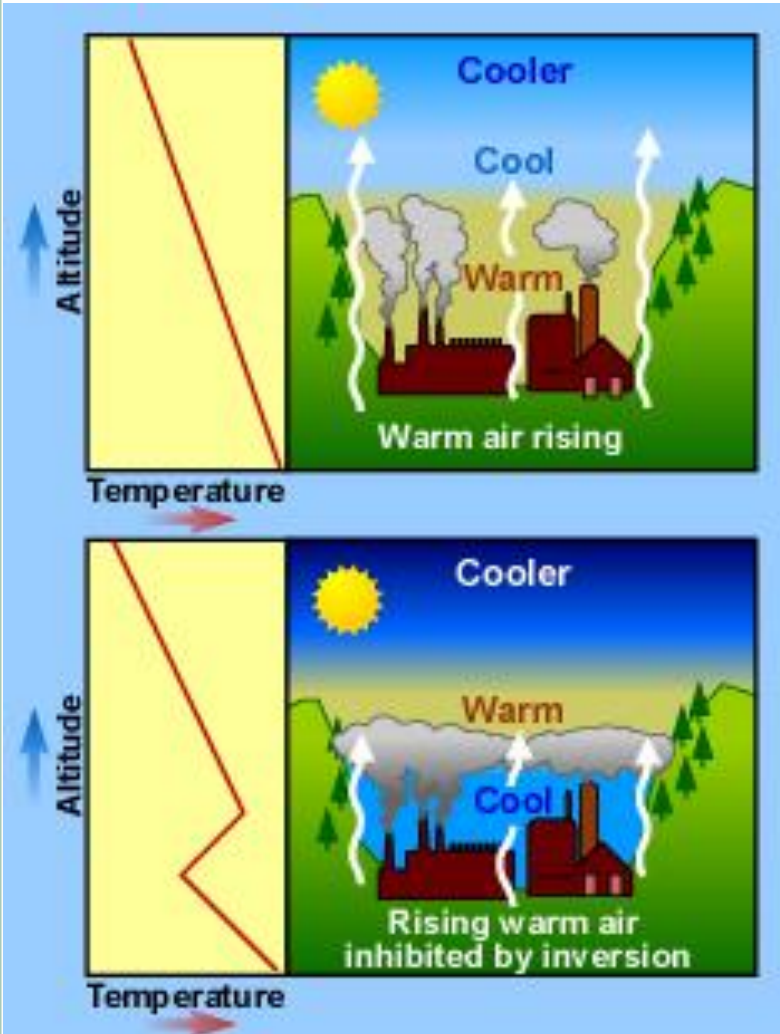
FACTORS AFFECTING AIR POLLUTION

LEVEL: **ATMOSPHERIC STABILITY**

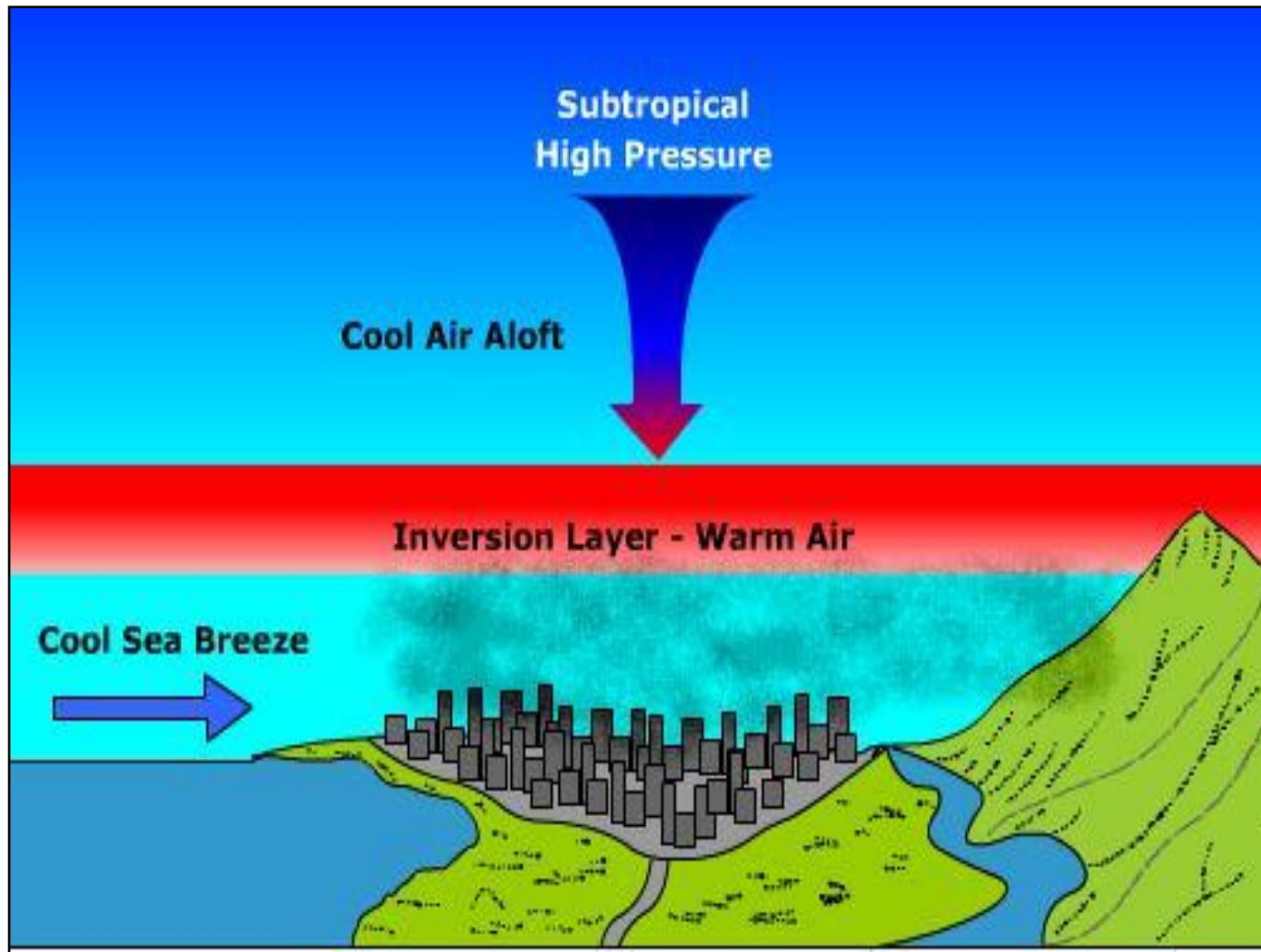
☒ During a temperature inversion, air pollution released into the atmosphere's lowest layer is trapped there and can be removed only by strong horizontal winds.

☒ Because high-pressure systems often combine temperature inversion conditions and low wind speeds, their long residency over an industrial area usually results in episodes of severe smog.

☒ These inversions near the surface often occur in the early morning hours before sunrise



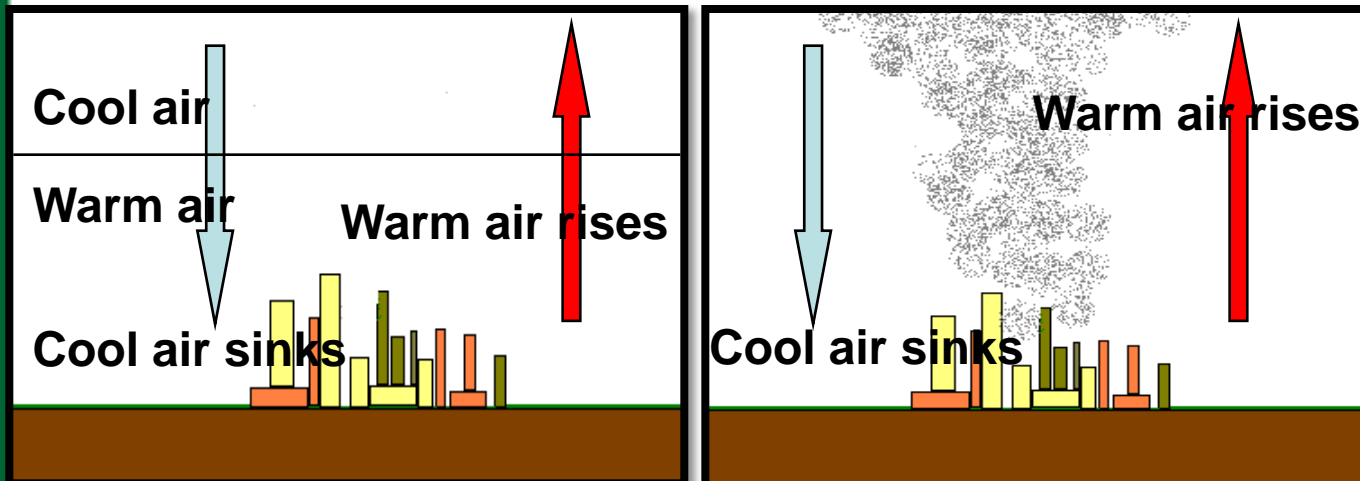
FACTORS AFFECTING AIR POLLUTION LEVEL: **ATMOSPHERIC STABILITY**



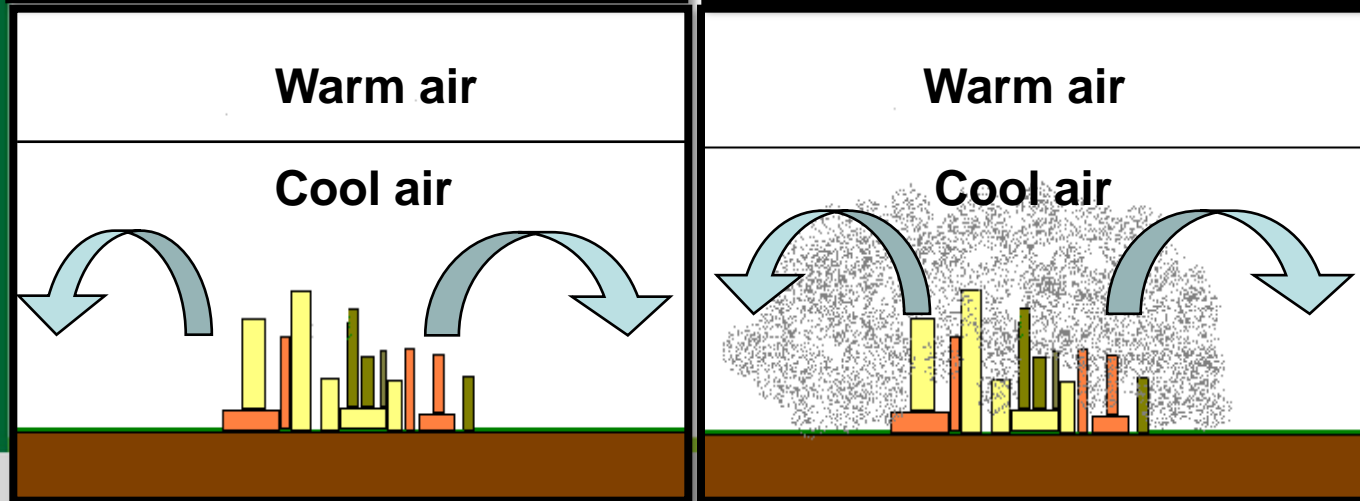
Atmospheric stability

How this will effect air pollution level?

Through the ability of the atmosphere to disperse pollutants.



- Unstable atmosphere
- Air move naturally in a vertical direction
- carry pollutants upward, away from the ground



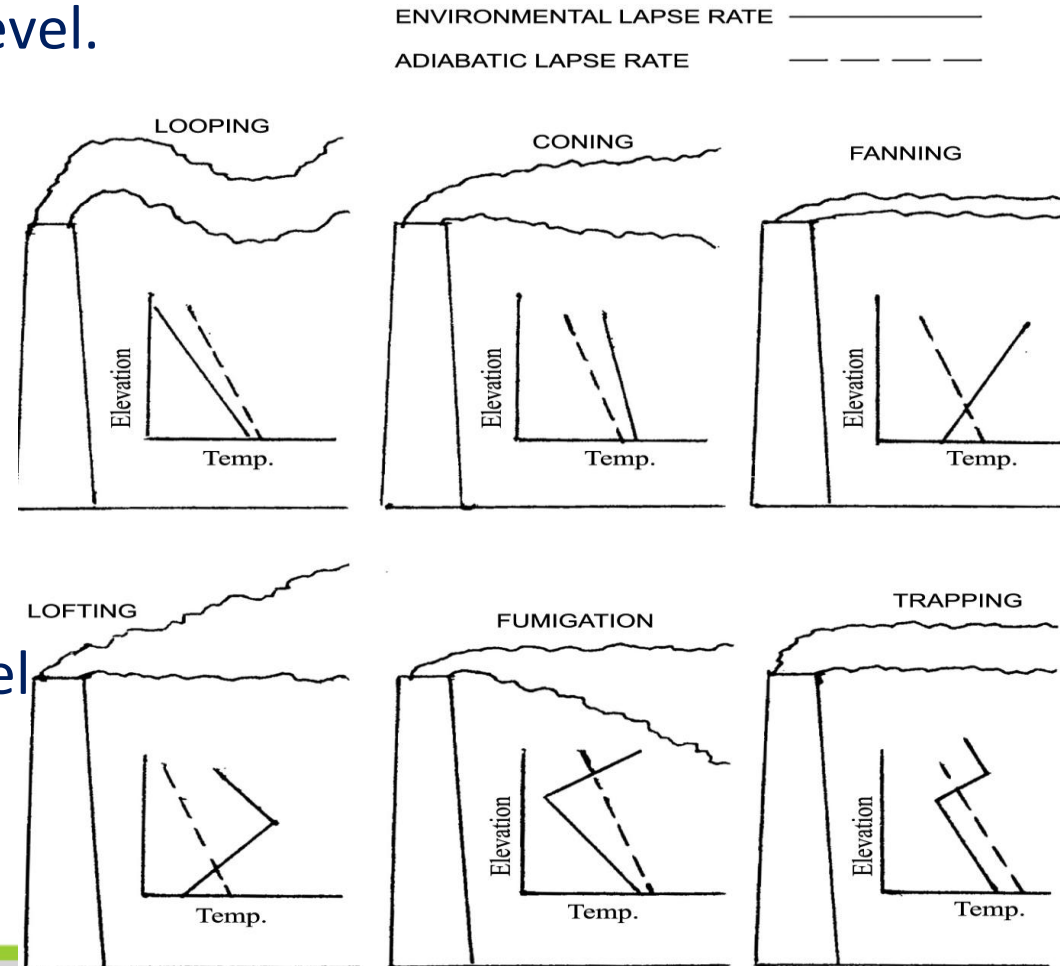
- Stable atmosphere
- no mixing of air pollutants in the vertical direction
- pollutants tend to accumulate near the ground.

FACTORS AFFECTING AIR POLLUTION LEVEL: **TYPE OF PLUME**

Plume types are important because they help us understand under what conditions there will be higher concentrations of contaminants at ground level.

- Looping plume
- Coning plume
- Fanning plume
- Lofting plume
- Fumigation plume

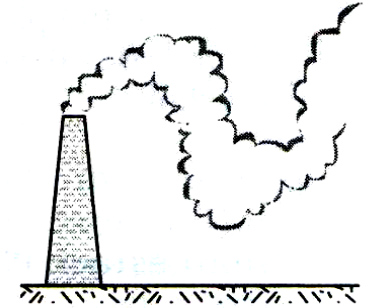
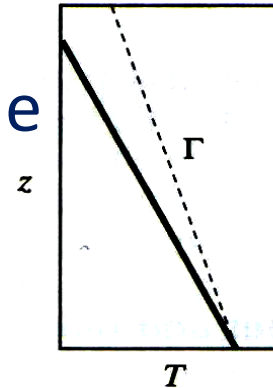
Gaussian Dispersion Model



Note: Following Henry and Heincke (1996)

FACTORS AFFECTING AIR POLLUTION LEVEL: **TYPE** **OF PLUME**

Looping Plume



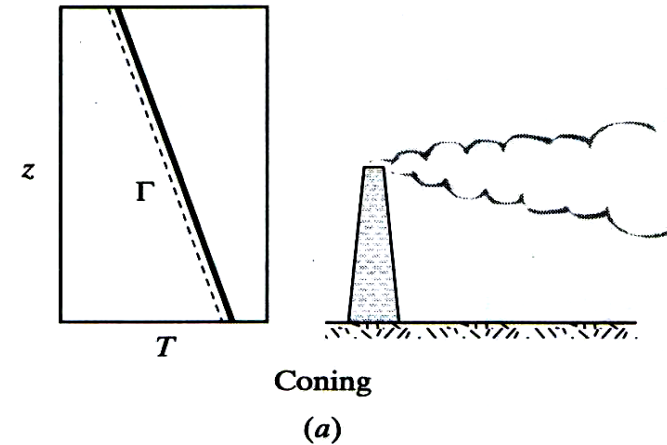
Looping
(b)

- ❑ High degree of convective turbulence
- ❑ Super-adiabatic lapse rate-- strong instabilities
- ❑ Associated with clear daytime conditions accompanied by strong solar heating & light winds
- ❑ High probability of high concentrations sporadically at ground level close to stack.
- ❑ Occurs in unstable atmospheric conditions.



FACTORS AFFECTING AIR POLLUTION LEVEL: **TYPE** **OF PLUME**

Coning Plume

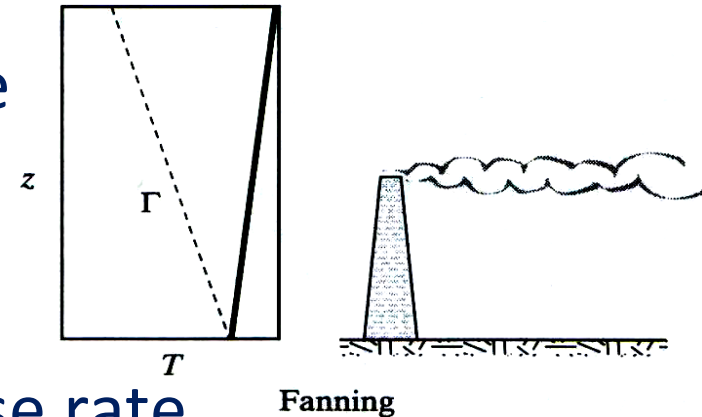


- ❑ Stable with small-scale turbulence
- ❑ Associated with overcast moderate to strong winds
- ❑ Roughly 10° cone
- ❑ Pollutants travel fairly long distances before reaching ground level in significant amounts
- ❑ Occurs in neutral atmospheric conditions



FACTORS AFFECTING AIR POLLUTION LEVEL: **TYPE** **OF PLUME**

Fanning Plume

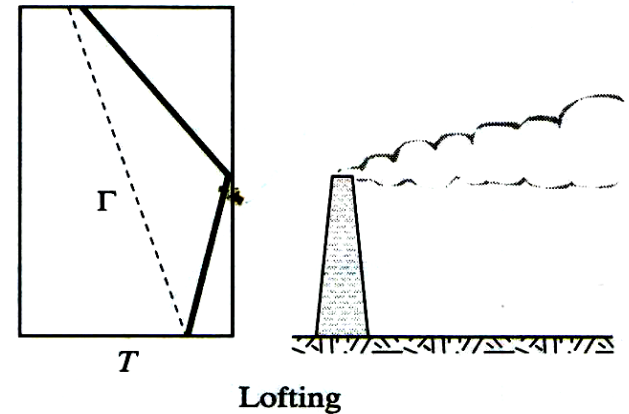


- ❑ Occurs under large negative lapse rate
- ❑ Strong inversion at a considerable distance above the stack
- ❑ Extremely stable atmosphere
- ❑ Little turbulence
- ❑ If plume density is similar to air, travels downwind at approximately same elevation



FACTORS AFFECTING AIR POLLUTION LEVEL: **TYPE OF PLUME**

Lofting Plume z

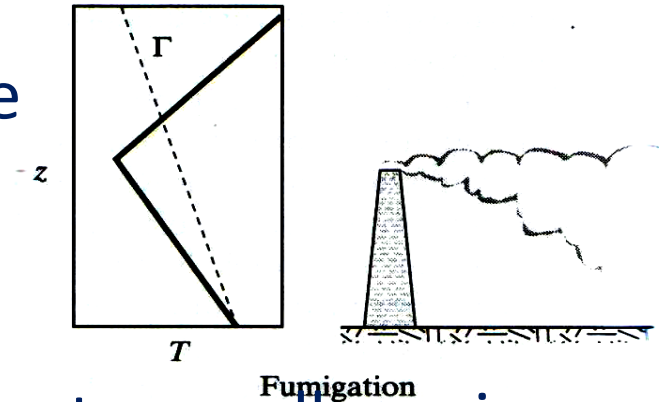


- ❑ Favorable in the sense that fewer impacts at ground level.
- ❑ Pollutants go up into environment.
- ❑ They are created when atmospheric conditions are unstable above the plume and stable below.



FACTORS AFFECTING AIR POLLUTION LEVEL: **TYPE** **OF PLUME**

Fumigation Plume



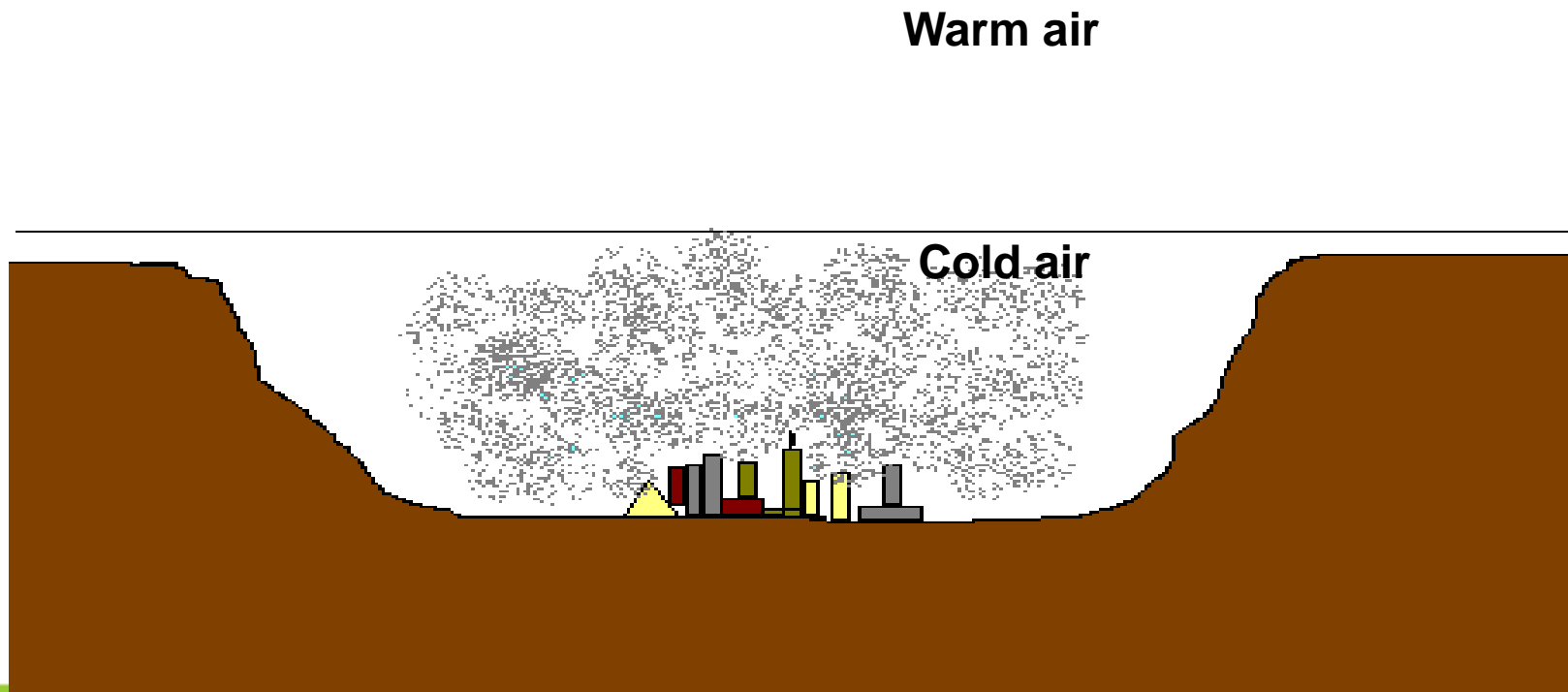
- ❑ Most dangerous plume: contaminants are all coming down to ground level.
- ❑ They are created when atmospheric conditions are stable above the plume and unstable below.
- ❑ This happens most often after the daylight sun has warmed the atmosphere, which turns a night time fanning plume into fumigation for about a half an hour.



FACTORS AFFECTING AIR POLLUTION

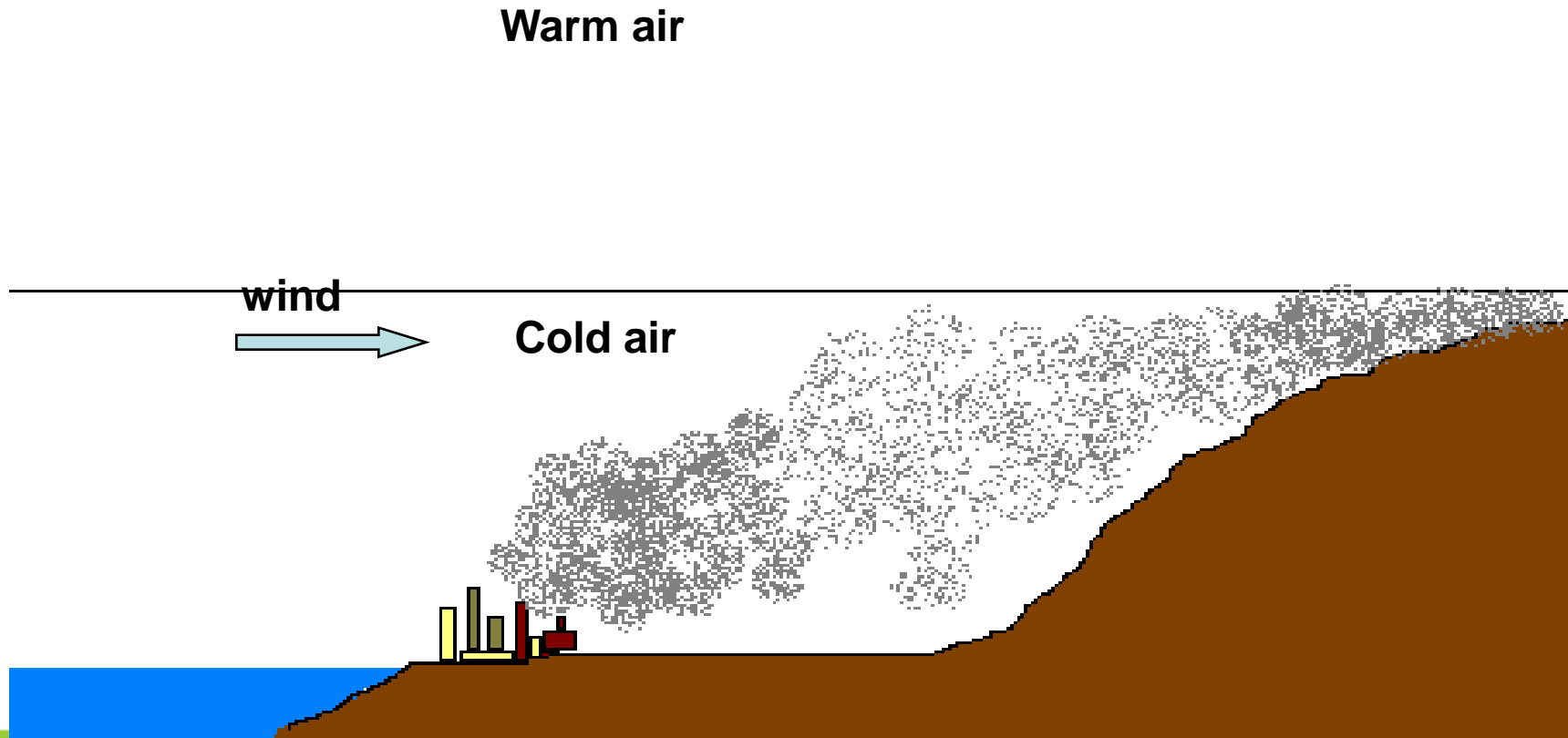
LEVEL: TOPOGRAPHY

- ✚ Certain Topographical and atmospheric stability conditions may also aggravate air pollution problems



FACTORS AFFECTING AIR POLLUTION

LEVEL: TOPOGRAPHY



IN A NUTSHELL... FACTORS AFFECTING AIR POLLUTION LEVEL

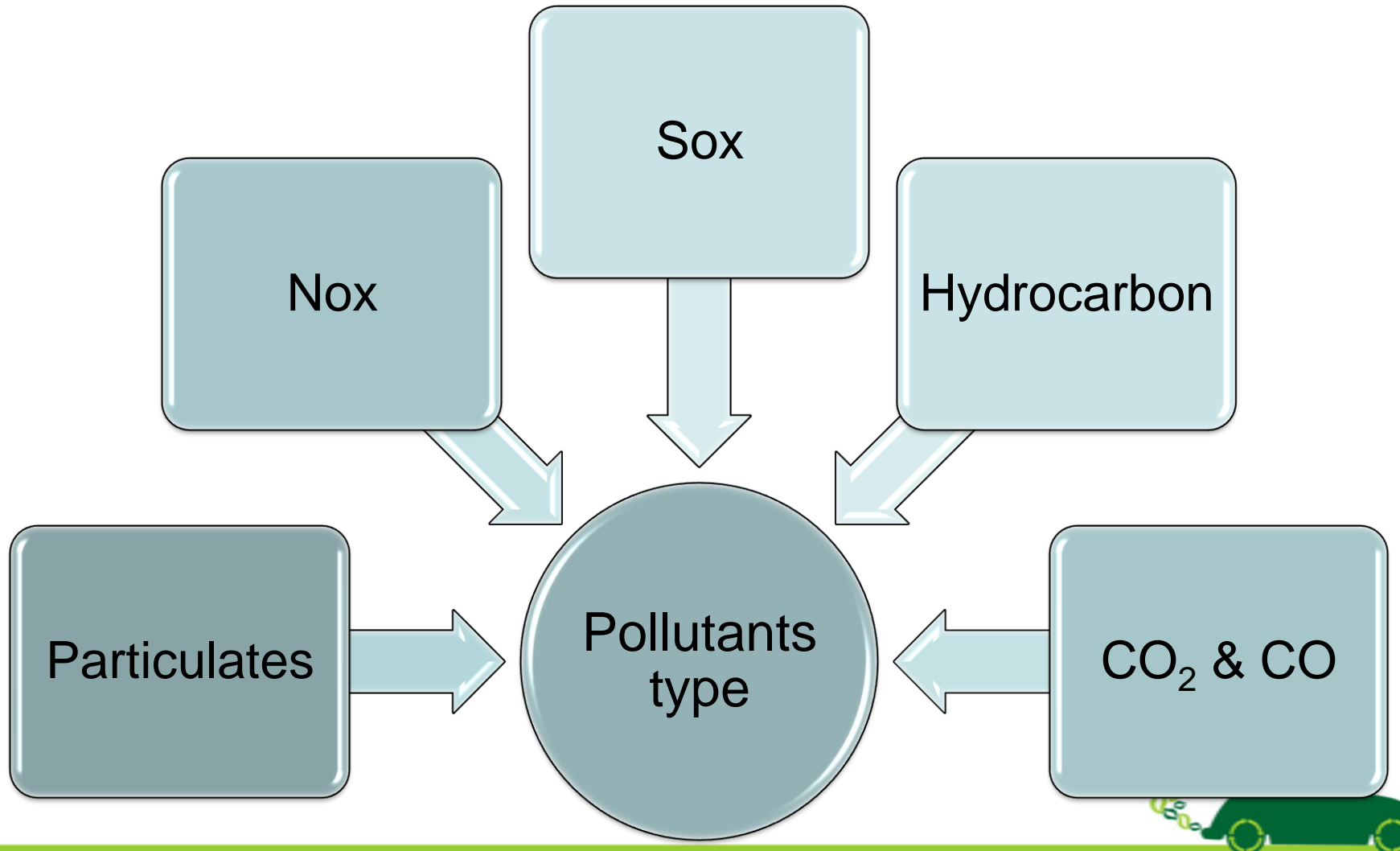
Wind : horizontal dispersion

Atmospheric stability :
vertical dispersion

Topography: concentrated
dispersion

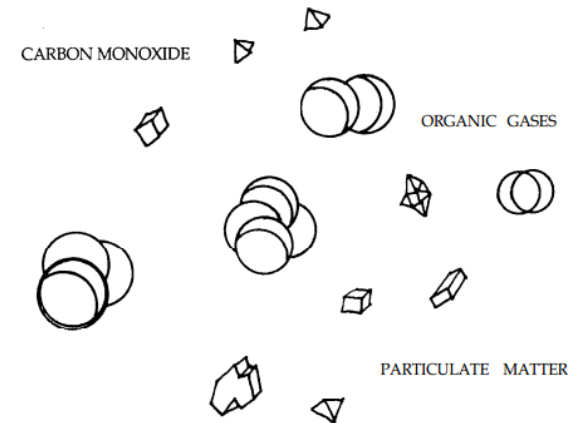


TYPES OF AIR POLLUTANTS



TYPES OF AIR POLLUTANTS: PARTICULATE MATTERS

- ❑ Particulate matter in the atmosphere in solids or liquid form
- ❑ Includes wind-blown soil, soot, smoke, aerosol, dust, fly ash, fumes and fog
- ❑ which are size are $0.0002\mu\text{m} \sim 500\mu\text{m}$
- ❑ Particles are emitted into the air by sources such as factories, power plants, cars, construction activities, fires, and agricultural activities



	Coarse Particles (PM ₁₀)	Fine Particles (PM _{2.5})
What	<ul style="list-style-type: none"> • smoke, dirt and dust from factories, farming, and roads • mold, spores, and pollen 	<ul style="list-style-type: none"> • toxic organic compounds • heavy metals
Source	<ul style="list-style-type: none"> • crushing and grinding rocks and soil blown by wind • burning plants (brush fires and forest fires or yard waste) 	<ul style="list-style-type: none"> • driving automobiles • burning plants (brush fires and forest fires or yard waste) • smelting (purifying) and processing metals

TYPES OF AIR POLLUTANTS: PARTICULATE MATTERS

- Parameters : for the calculation of API, Malaysia will only consider PM_{10} (Particulate matter size $< 10\mu m$)
 - "Inhalable coarse particles," such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than 10 micrometers in diameter.
 - "Fine particles," such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.



TYPES OF AIR POLLUTANTS: PARTICULATE MATTERS

❏ Effects:

- ❏ Respiratory illness, bronchitis, even deaths
- ❏ Many of the small particles from wood smoke are too small to be filtered by the nose or upper respiratory system and able to penetrate deep within the lungs
- ❏ Due to their ability to evade the defenses of the body, these particles transporting toxic gases, bacteria, and viruses into the lungs, and ultimately the blood stream.
- ❏ Black Carbon Pollution: released tiny particles from fuel burning for energy production; major problem since industrial revolution
- ❏ Case : London Black Fog → Tiny particulate air pollution from coal stoves that killed 4000 people.



TYPES OF AIR POLLUTANTS: NITROGEN OXIDES (NO_x)

- ❑ The primary form of nitrogen oxide emissions is nitric oxide (NO) and nitrogen dioxide (NO_2) as they are emitted in significant quantities to the atmosphere; N_2O (nitrous oxide), N_2O_3 (sesquioxide), N_2O_4 (tetraoxide) and N_2O_5 (pentoxide)
- ❑ Major sources of nitrogen oxides include:
 - ❑ Fuel combustion in power plants and automobiles
 - ❑ Processes used in chemical plants
- ❑ This gas is rapidly converted in the atmosphere, in the presence of volatile organic compounds and sunlight, the nitrogen dioxide can be subsequently decomposed to produce ozone



TYPES OF AIR POLLUTANTS: NITROGEN OXIDES (NO_x)

Formation of acid
 HNO_2

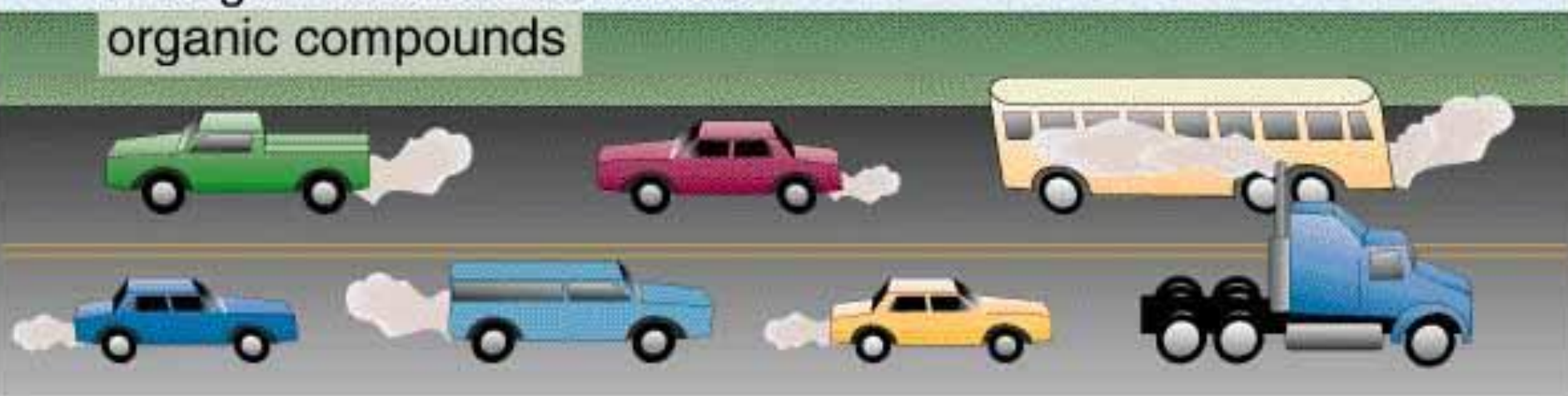
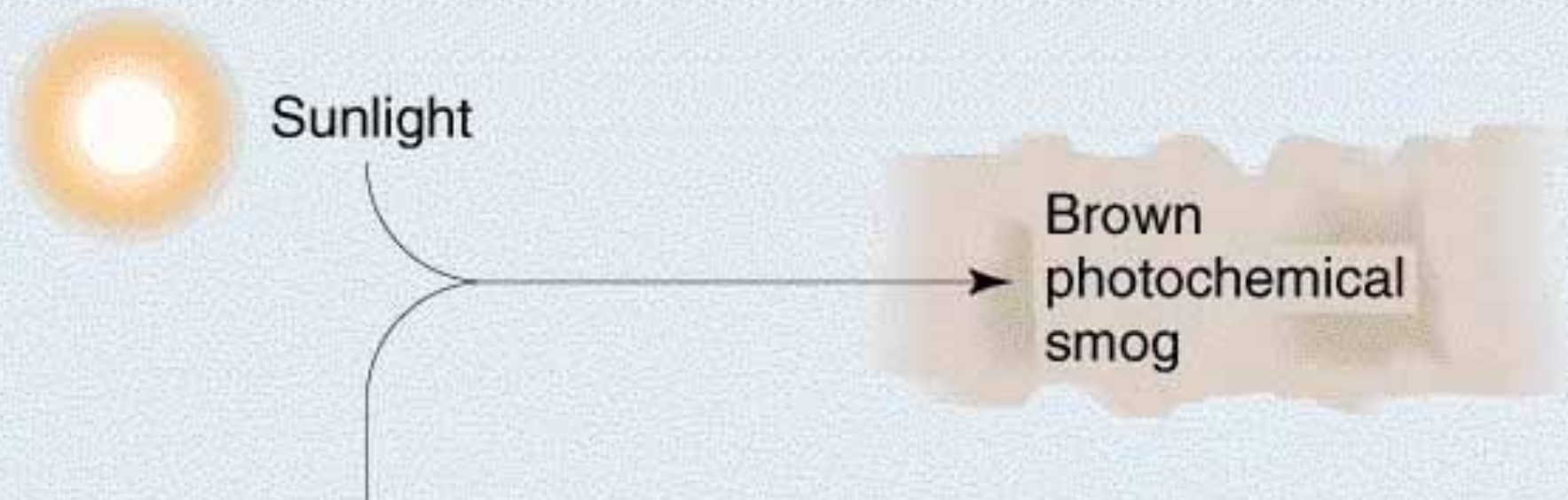
Photochemical
smog formation

Effects

Greenhouse gases
(N_2O)

Damaging plants





(b) Photochemical smog





TYPES OF AIR POLLUTANTS: SULFUR OXIDE (SO_x)

- ❑ Sulfur oxide is colorless, non-flammable and non-explosive highly reactive gasses with a suffocating odor.
- ❑ It reacts on the surface of a variety of airborne solid particles, is soluble in water and can be oxidized within airborne water droplets.
- ❑ Sulphur dioxide (SO₂) and sulphur trioxide (SO₃) are of most interest in the study of air pollution.
- ❑ In the atmosphere, sulfur dioxide mixes with water vapor producing sulfuric acid, transported by wind over many hundreds of miles, and deposited as acid rain.



TYPES OF AIR POLLUTANTS: SULFUR OXIDE (SO_x)

- ❏ **Natural sources** of SO₂ : releases from volcanoes, oceans, biological decay and forest fires.
- ❏ **Man-made sources** of SO₂ : includes fossil fuel combustion, smelting, manufacture of sulfuric acid, conversion of wood pulp to paper and incineration
- ❏ SO₂ causes irritation and permanent damage to the lungs. Inhalable sulfate particulate matter formed from SO₂ can impair visibility.
- ❏ SO₂ also contributes to the formation of acid rain, which damages plant , animal, buildings and electrical equipment.



TYPES OF AIR POLLUTANTS: CARBON OXIDE (CO_x)

- ❑ Carbon forms with oxygen 2 environmentally important gases of carbon monoxide (CO) and carbon dioxide (CO₂). Carbon oxides are significant components of the atmosphere and it is part of carbon cycle.
- ❑ Carbon dioxide is naturally produced by respiration and metabolism and consumed by plants during photosynthesis.
- ❑ Carbon dioxide is a greenhouse gas that traps the earth's heat and contributes to climate change
- ❑ Carbon monoxide (CO) is a colorless, odorless gas emitted from incomplete combustion process and caused indoor pollution



CO₂AS GREENHOUSE GASES

Global warming: Causes and effects

Earth's temperature has risen about 1 degree Fahrenheit in the last century. The past 50 years of warming has been attributed to human activity.

Burning fuels such as coal, natural gas and oil produces greenhouse gases in excessive amounts.

Greenhouse gases are emissions that rise into the atmosphere and trap the sun's energy, keeping heat from escaping.

The United States was responsible for 20 percent of the global greenhouse gases emitted in 1997.

Most of the world's emissions are attributed to the United States' large-scale use of fuels in vehicles and factories.

During the past 100 years global sea levels have risen 4 to 8 inches.

Some predictions for local changes include increasingly hot summers and intense thunderstorms.



Damaging storms, droughts and related weather phenomena cause an increase in economic and health problems. Warmer weather provides breeding grounds for insects such as malaria-carrying mosquitoes.

TYPES OF AIR POLLUTANTS: CARBON OXIDE (CO_x)

- ❑ Particularly in urban areas, the majority of CO emissions to ambient air come from mobile sources. Other major sources are wood-burning stoves, incinerators and industrial sources
- ❑ CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues.
- ❑ At extremely high levels, CO can cause death because carbon monoxide binds to hemoglobin so strongly, you can be poisoned even at very low concentrations if you are exposed for a long period of time.



TYPES OF AIR POLLUTANTS: HYDROCARBONS

- ❏ Hydrocarbons are a class of reactive organic gases formed solely from hydrogen and carbon through the incomplete burning of any organic matter such as oil, wood or rubber.
- ❏ Primary source: combustion engine exhaust, oil refineries and oil-fuelled power plants
- ❏ Other source: evaporation from petroleum fuels (e.g. at service stations), solvents, dry cleaning solutions and paint. Hydrocarbons can also arise from unburnt hydrocarbons in exhausts



TYPES OF AIR POLLUTANTS: HYDROCARBONS

- ❑ The health effects from hydrocarbons are similar to those from exposure to ozone as hydrocarbons assist in the formation of ozone.
- ❑ High levels of hydrocarbons in the atmosphere can reduce the amount of available oxygen.
- ❑ Carcinogenic (cancer causing) forms of hydrocarbons are considered hazardous air pollutants, or air toxins and can lead to the development of cancer.



PRIMARY & SECONDARY AIR POLLUTANT

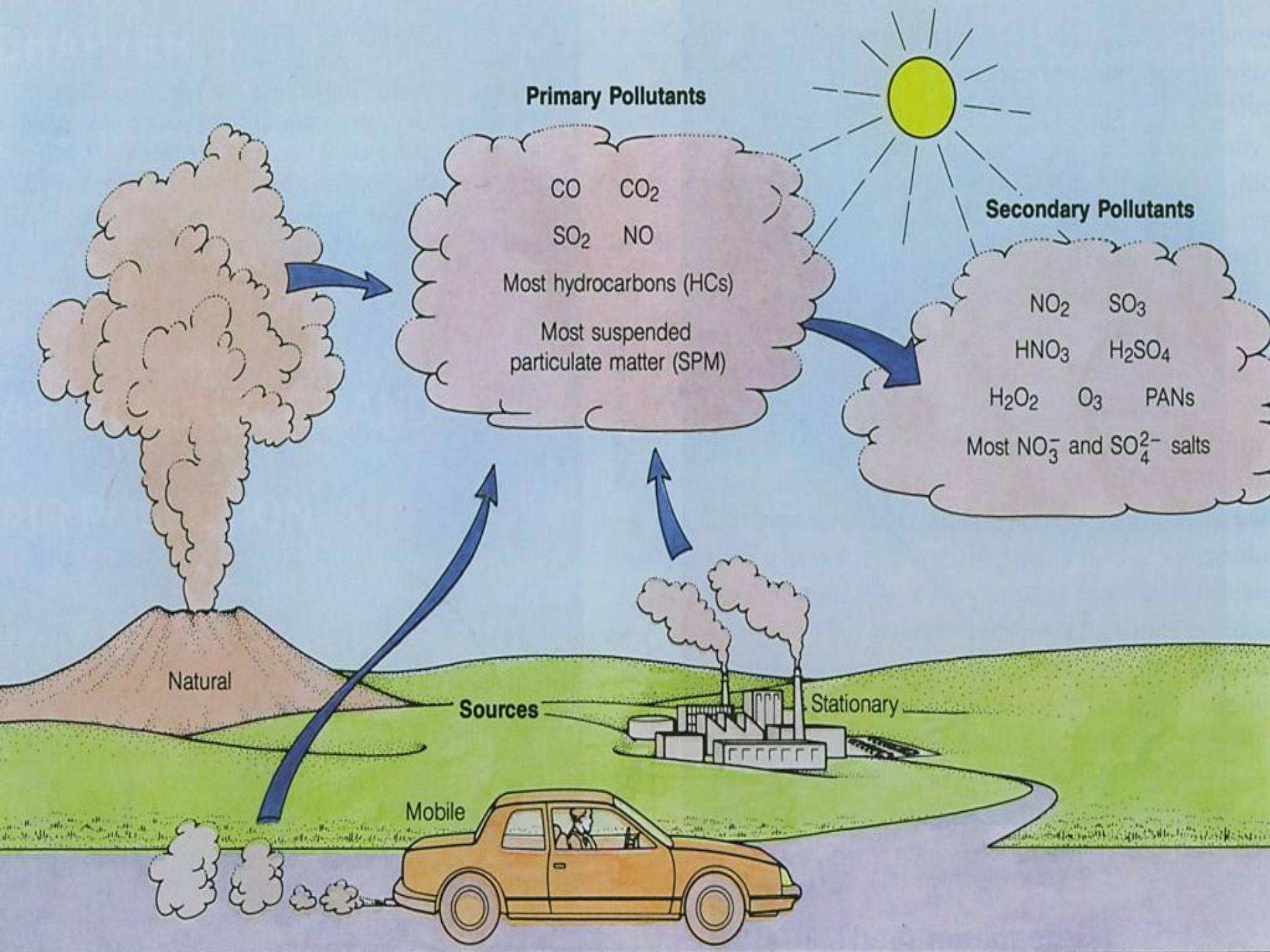
❑ PRIMARY AIR POLLUTANT

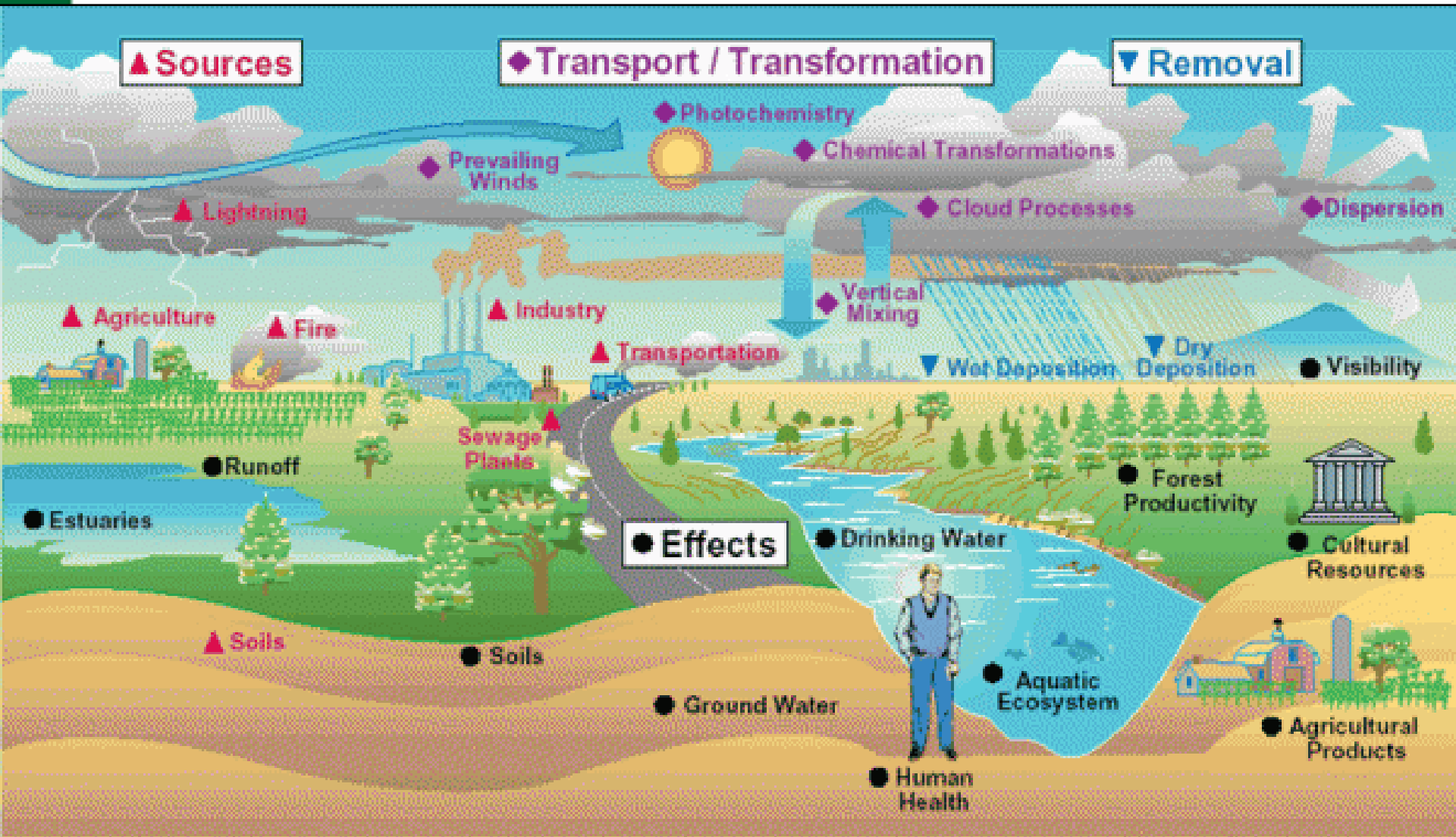
- ❑ Enters directly into the atmosphere from natural events or human activities
- ❑ CO, CO₂, SO₂, NO, most hydrocarbons, most particulates

❑ SECONDARY AIR POLLUTANT

- ❑ Is formed in the atmosphere through chemical reaction and solar reaction
- ❑ NO₂, SO₃, HNO₃, H₂SO₄, H₂O₂, O₃, PAN (peroxyacetyl nitrate)









QUESTION?

