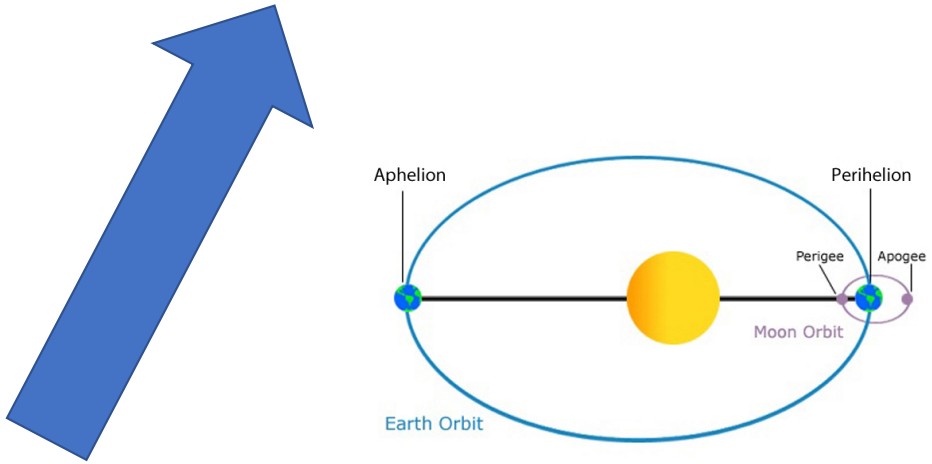
THE UNIVERSITY OF UTAH

ATMOS 5140
Lecture 4 – Chapter 3

- Electromagnetic Spectrum
- Applications
  - Ozone Layer
  - Photochemical Smog

Insolation

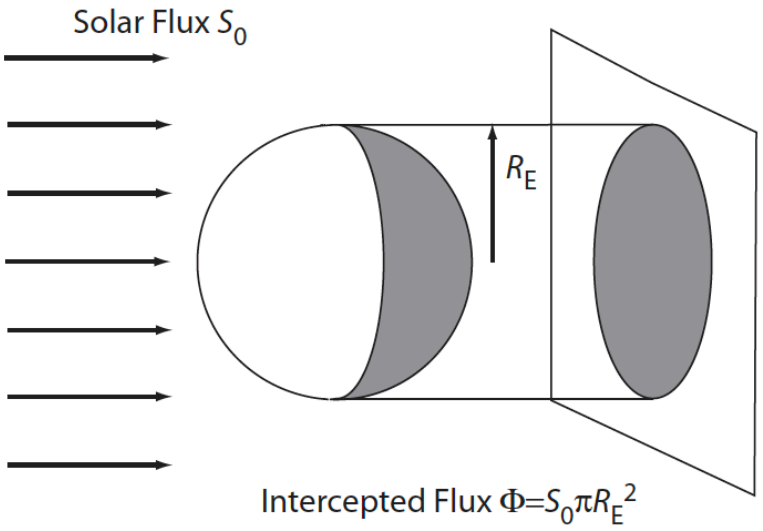
$$S_0 = 1370 \ \ \mathrm{W\ m^{-2}}.$$



- Thus not really constant
- Varies from 1330 W/m^2 to 1420 W/m^2

Insolation

$$S_0 = 1370 \ \text{W m}^{-2}.$$



$$\Phi = S_0 \pi R_E^2 = 1.74 \times 10^{17} \ \text{W}$$

Fig. 2.7: The total flux of solar radiation intercepted by the earth is equal to the product of the incident flux density S_0 and the area of the earth's shadow.

Insolation

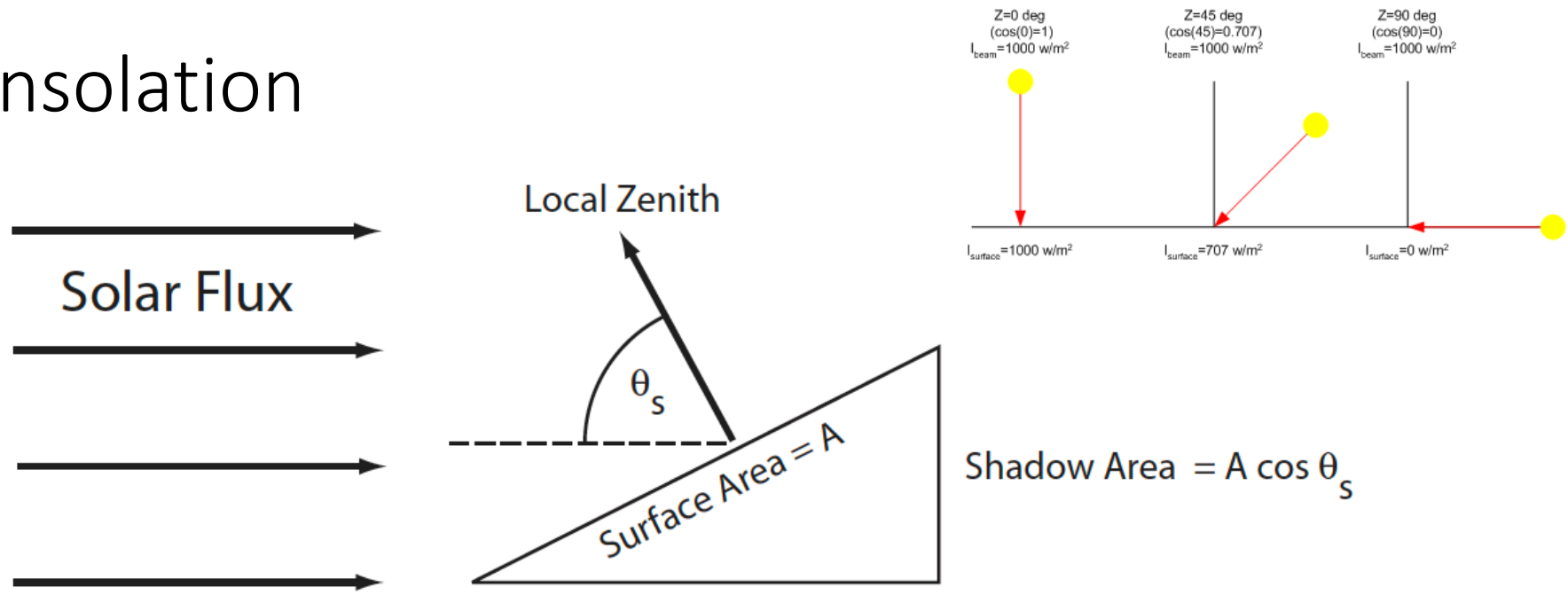


Fig. 2.8: The relationship between local solar zenith angle θ_s and insolation on a local horizontal plane.

$$F = S_0 \cos\theta_s \ .$$

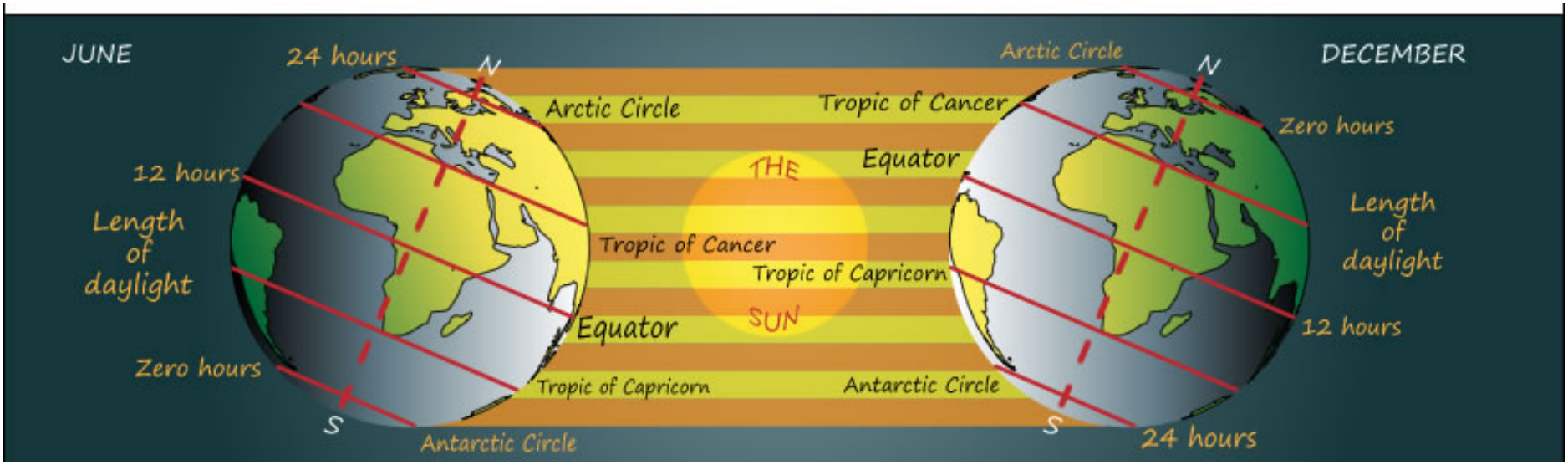
Insolation

- Total insolation at the top of the atmosphere at a single location

$$W = \int_{t_{\text{sunrise}}}^{t_{\text{sunset}}} S_0 \cos\theta_s(t)\ dt.$$

  - Depends on
    - Length of Day
    - Average values of sun angle (while sun is up): $\cos\theta_s$(t)

Insolation

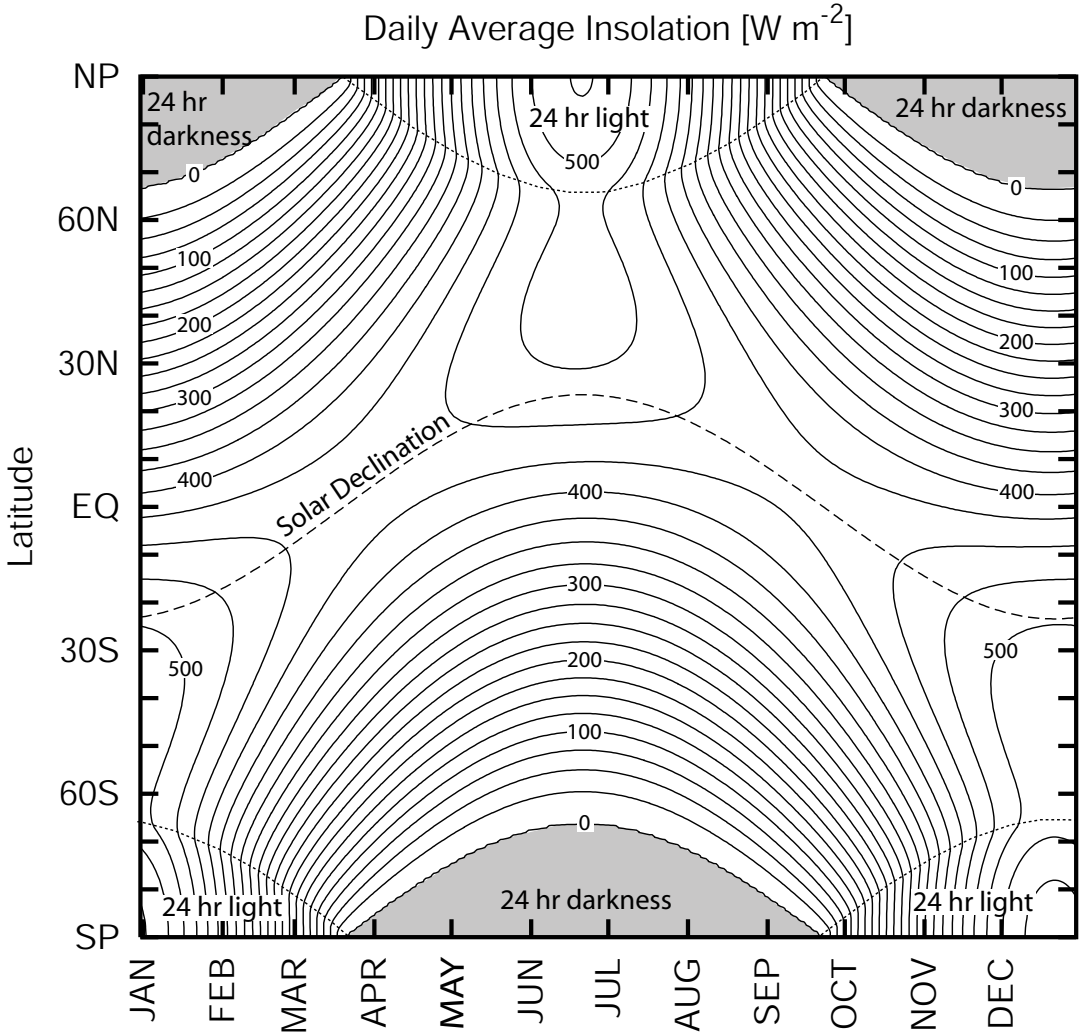

JUNE
24 hours
N
Arctic Circle
12 hours
Length of daylight
Zero hours
S
Antarctic Circle
Tropic of Cancer
THE
Equator
Tropic of Capricorn
SUN
Equator
Tropic of Capricorn
Arctic Circle
Tropic of Cancer
Antarctic Circle
DECEMBER
N
Zero hours
Length of daylight
12 hours
S
24 hours

Insolation

At the top of the atmosphere!

Upper Bound

The rest of the class we will focus on how much of this radiation is absorbed and reflected



Insolation

At the top of the atmosphere!

Upper Bound

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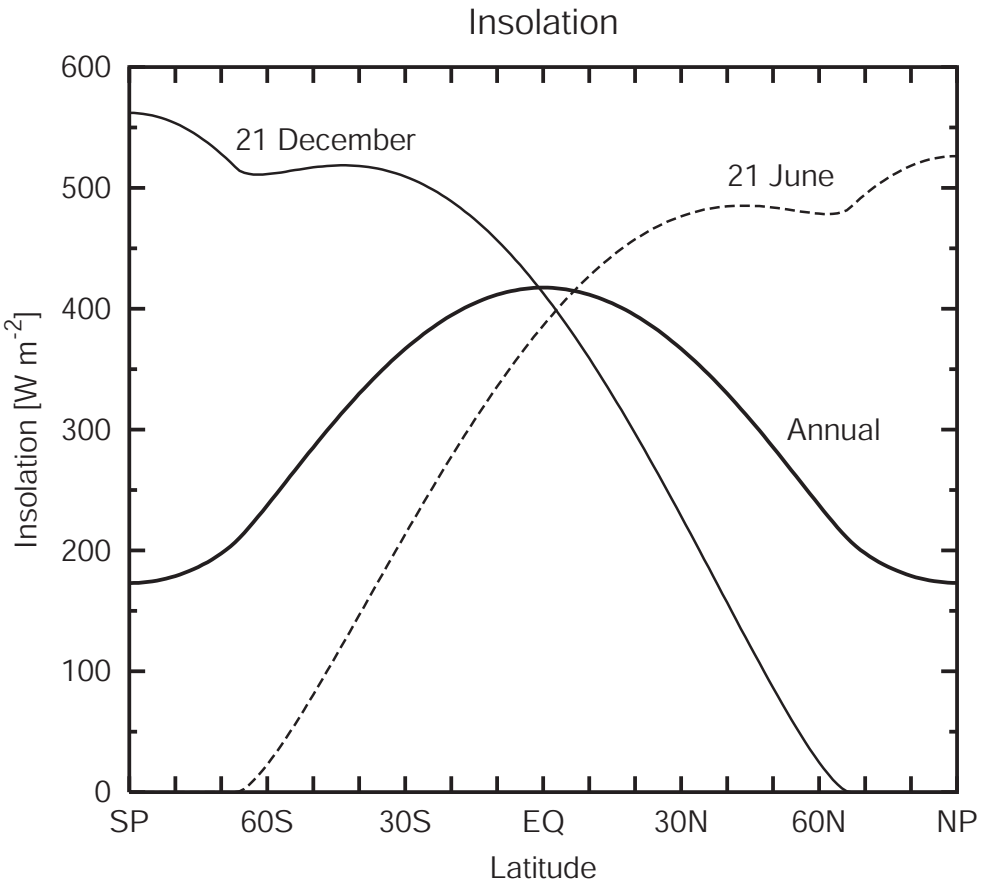
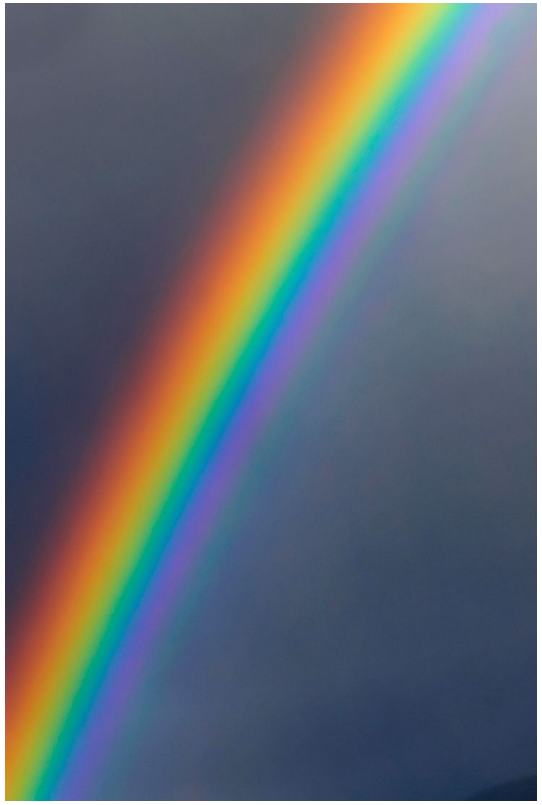
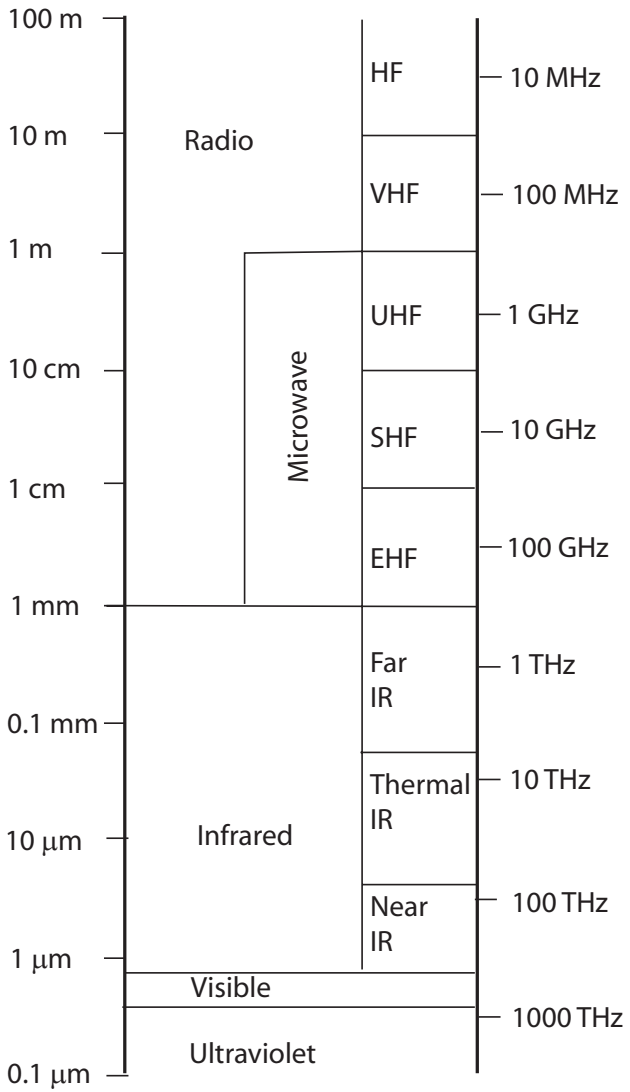


Spectrum




100 m
10 m
1 m
10 cm
1 cm
1 mm
0.1 mm
10 μm
1 μm
0.1 μm
Radio
Microwave
Infrared
Visible
Ultraviolet
HF
VHF
UHF
SHF
EHF
Far IR
Thermal IR
Near IR
10 MHz
100 MHz
1 GHz
10 GHz
100 GHz
1 THz
10 THz
100 THz
1000 THz

Key point

- When considering radiation is scattered or reflected from particles
  - Dimension of the particle must be comparable to or larger than the wavelength

Real World Application
Radar = Microwave Band

Frequency band	Frequency range (GHz)	Wavelength range (cm)
L band	1–2	15–30
S band	2–4	7.5–15
C band	4–8	3.75–7.5
X band	8–12	2.5–3.75
Ku band	12–18	1.67–2.5
K band	18–27	1.11–1.67
Ka band	27–40	0.75–1.11
V band	40–75	0.4–0.75
W band	75–110	0.27–0.4

NWS
TV
DOW

Used for Precipitation

Real World Application

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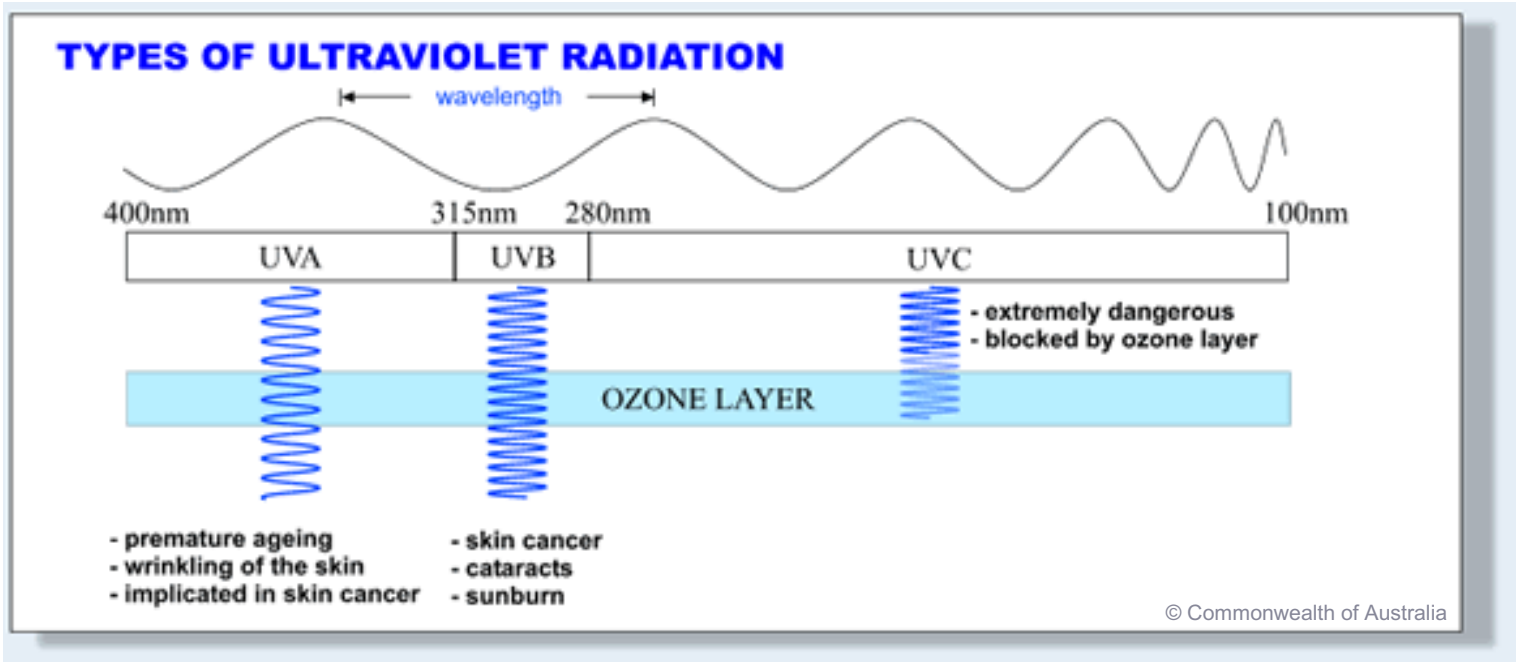
More Research Focused

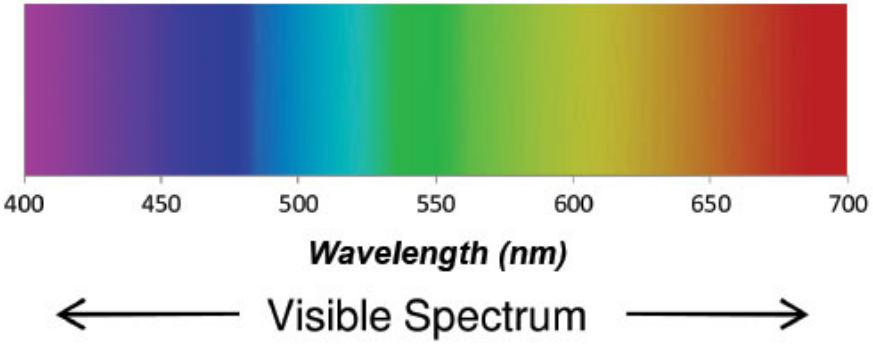
Detect Clouds, but not able to penetrate far through precipitation

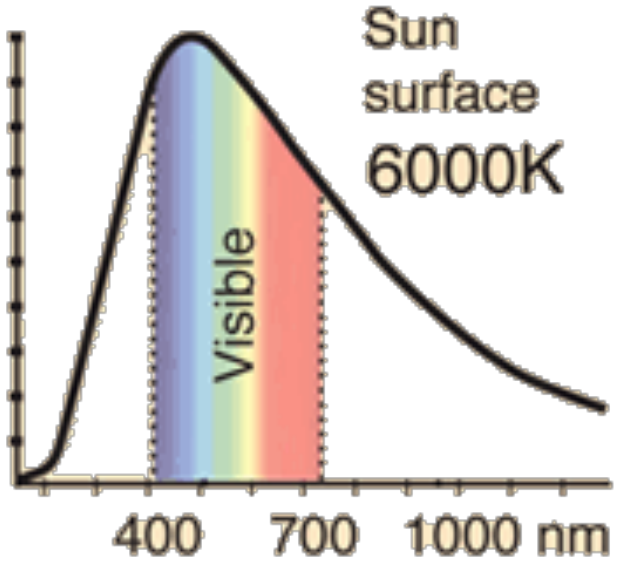
Ultraviolet Radiation



99% of UV reaching sea level

Visible Spectrum





Visible Band = Max emission of radiation by the sun

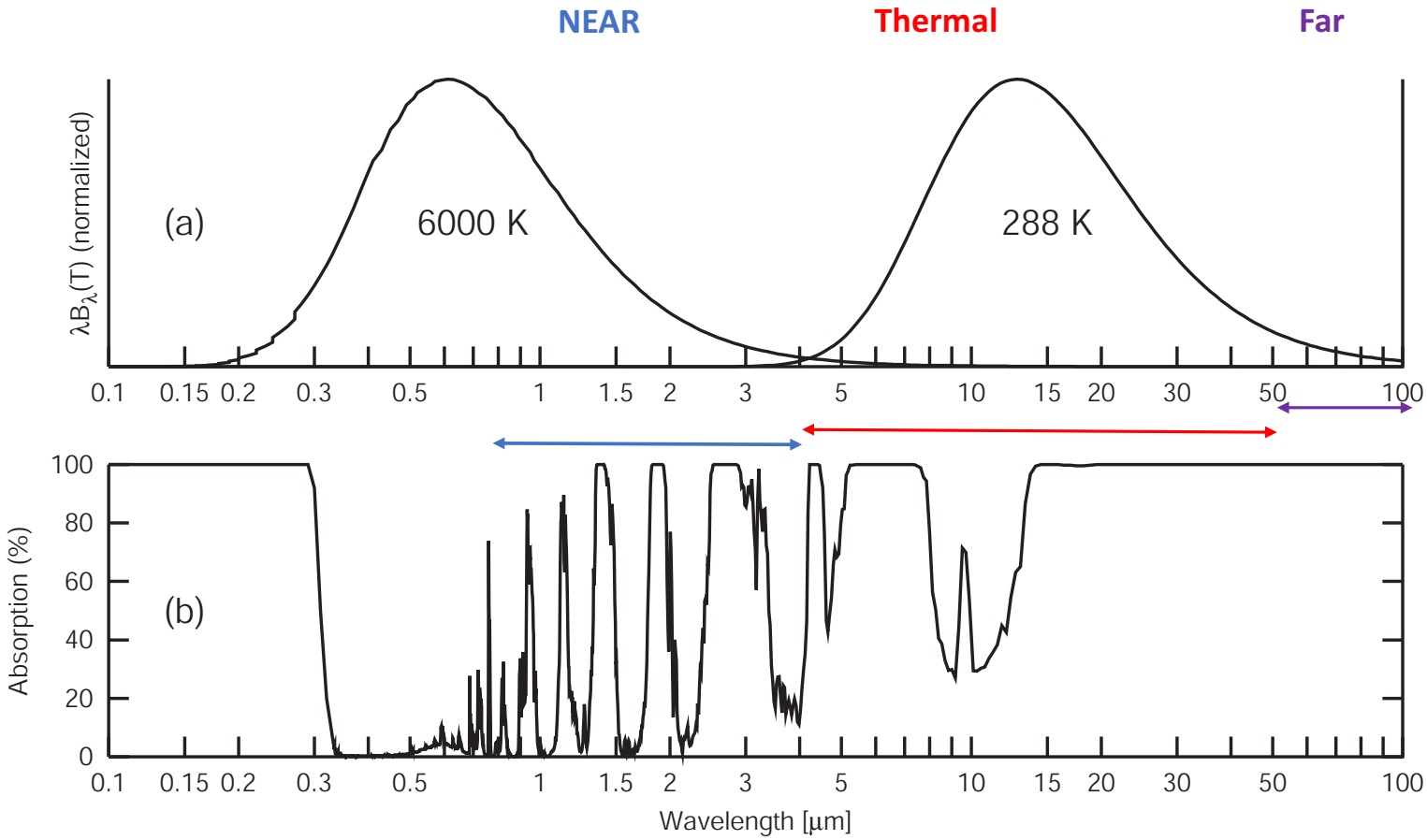
Cloud-free atmosphere is remarkably transparent to all visible wavelengths

Thus atmosphere is largely heated from below!

Clouds remarkably reflective in the visible band

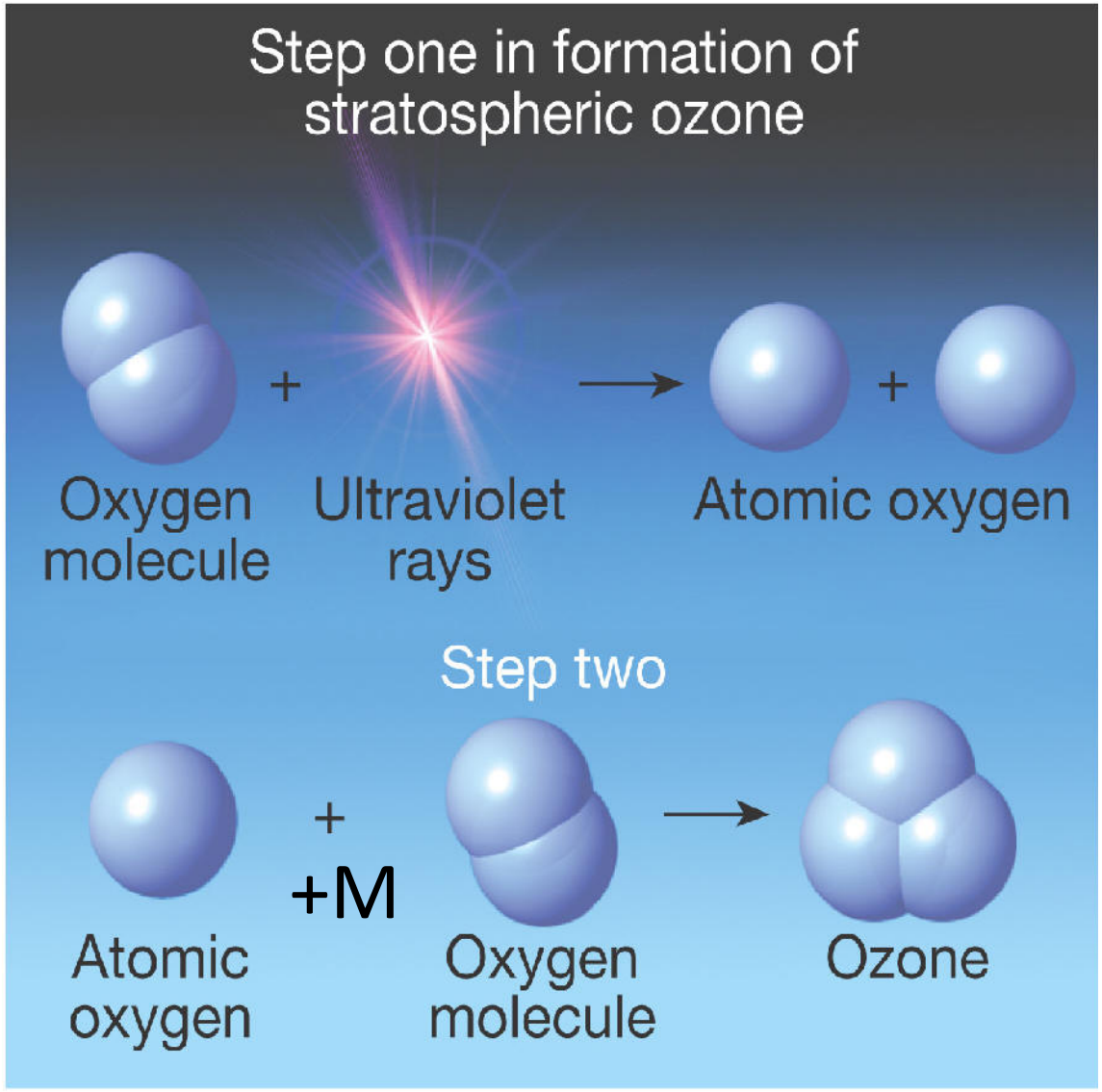
Thus, global distribution of clouds has huge influence on the radiation received by earth

Infrared Band



Ozone Layer

- Need light <0.2423 um



Photochemical Smog - SIMPLIED

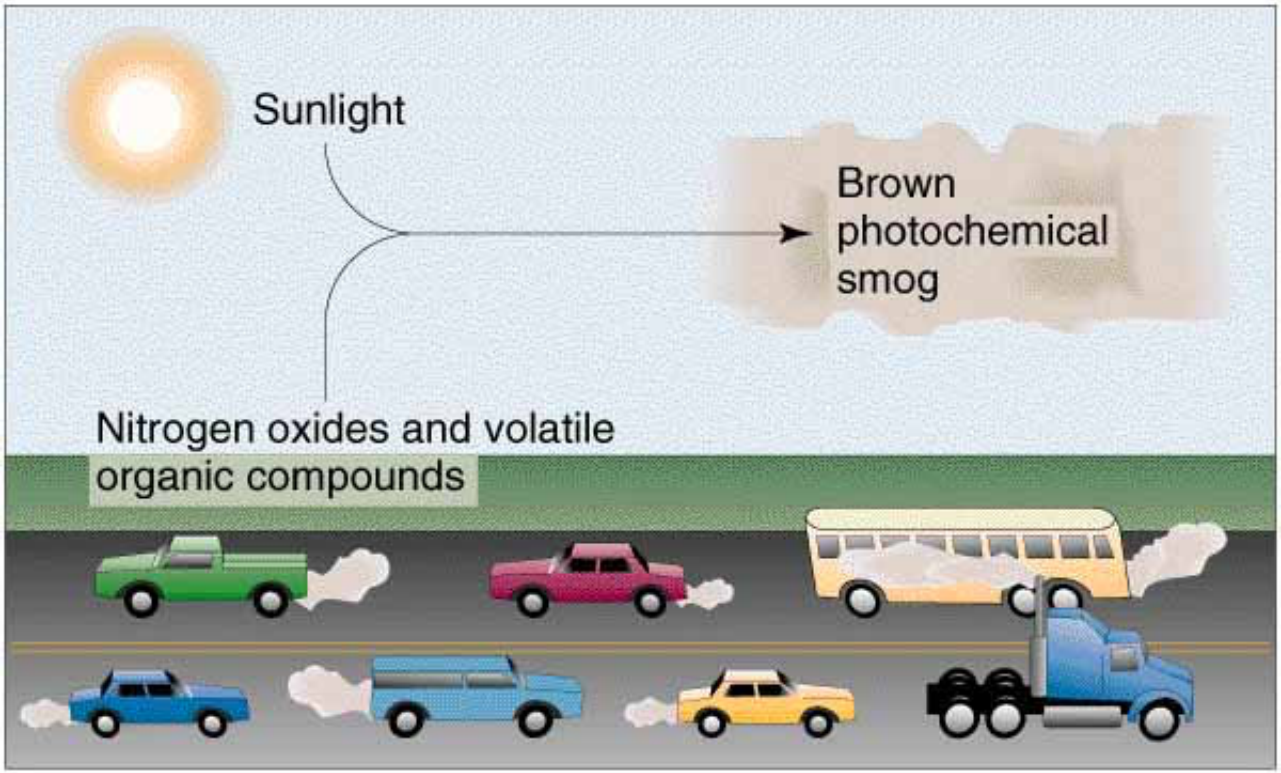
Eq. 1 $NO_2 + hv \rightarrow NO + O^{\cdot}$

Eq. 2 $O^{\cdot} + O_2 + M \rightarrow O_3 + M$

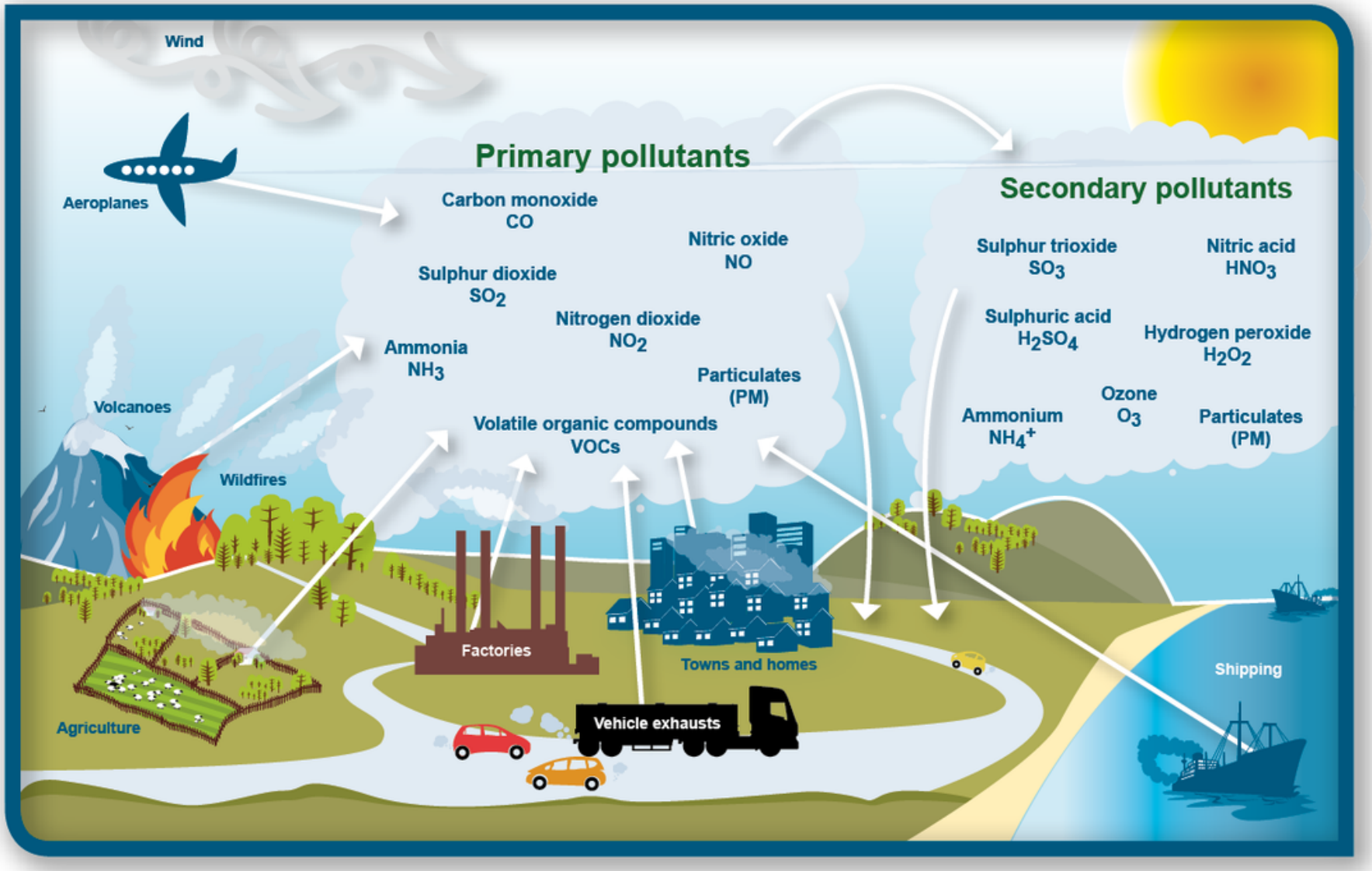
Eq. 3 $NO + O_3 \rightarrow NO_2 + O_2$

These reactions make O_3 and O

Photochemical Smog



(b) Photochemical smog


Wind
Aeroplanes
Primary pollutants
Carbon monoxide
CO
Nitric oxide
NO
Sulphur dioxide
SO_2
Nitrogen dioxide
NO_2
Ammonia
NH_3
Particulates
(PM)
Volatile organic compounds
VOCs
Secondary pollutants
Sulphur trioxide
SO_3
Nitric acid
HNO_3
Sulphuric acid
H_2SO_4
Hydrogen peroxide
H_2O_2
Ozone
O_3
Ammonium
NH_4^+
Particulates
(PM)
Volcanoes
Wildfires
Factories
Towns and homes
Vehicle exhausts
Agriculture
Shipping

Hydroxyl Radical