Radiation from the Sun

IB PHYSICS | ENERGY PRODUCTION

Intensity

$$Intensity = \frac{Power}{A}$$

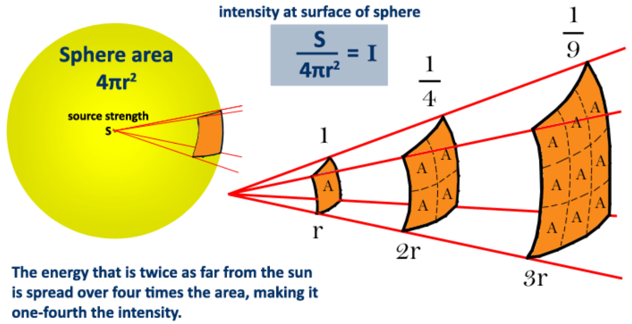
$$Units = \frac{W}{m^2} = Wm^{-2}$$

Intensity

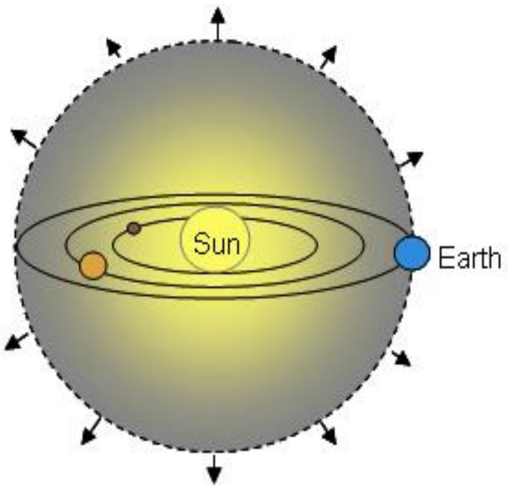
Calculate the intensity of the Sun's radiation arriving to Earth

Sun's Power = 3.84×10^{26} W

Earth's Distance from Sun = 150×10^{6} km



$$I = \frac{P}{A} = \frac{3.84 \times 10^{26}}{4\pi(150 \times 10^{9})^{2}}$$



$$I = 1358\ \mathrm{Wm^{-2}}$$

Solar Constant

The average intensity falling on an area above the earth's atmosphere perpendicular to the direction traveled by the radiation

$$S = 1360\ \text{W m}^{-2} = 1.36 \times 10^{3}\ \text{W m}^{-2}$$

Quantity	Symbol	Approximate value
Elementary charge	e	1.60×10^{-19} C
Electron rest mass	m_e	9.110×10^{-31} kg = 0.000549 u = 0.511 MeV c^{-2}
Proton rest mass	m_p	1.673×10^{-27} kg =1.007276 u = 938 MeV c^{-2}
Neutron rest mass	m_n	1.675×10^{-27} kg =1.008665 u = 940 MeV c^{-2}
Unified atomic mass unit	u	1.661×10^{-27} kg = 931.5 MeV c^{-2}
Solar constant	S	1.36×10^{3} W m^{-2}
Fermi radius	R_0	1.20×10^{-15} m

Average Solar Intensity on Earth

Earth's Radius = 6.37×10^{6} m

Area of sun power captured:

$$\pi r^2 = \pi(6.37 \times 10^6)^2 =$$

$$1.27 \times 10^{14}\ \mathrm{m}^2$$

Total sun power captured:

$$1.27 \times 10^{14}\ \mathrm{m}^2 \times \frac{1360\ \mathrm{W}}{1\ \mathrm{m}^2} =$$

$$1.7 \times 10^{17}\ \mathrm{W}$$

Average spread out across Earth's surface:

$$\frac{P}{A_{sphere}} = \frac{1.7 \times 10^{17}\ \mathrm{W}}{4\pi(6.37 \times 10^6)^2} =$$

$$340\ \mathrm{W\ m}^2$$

Total Power Received by the Earth 1.7×10^{17} W
Average Solar Intensity on Earth $340\ \mathrm{W\ m}^2$

Albedo vs. Emissivity

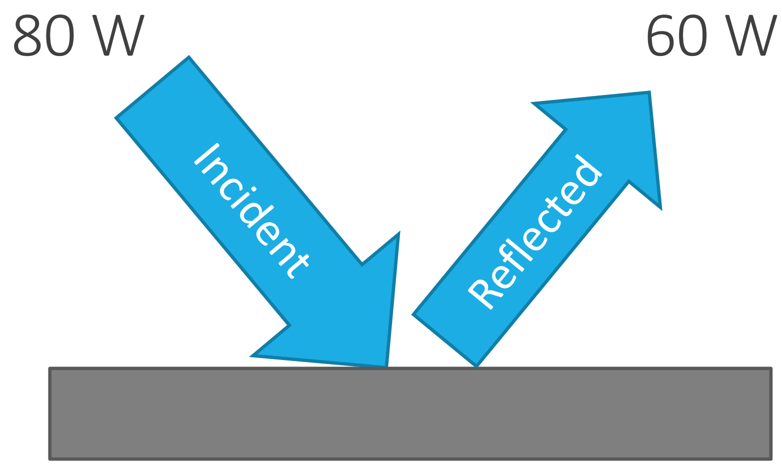
Albedo
$\frac{power\ scattered\ by\ a\ body}{incident\ power}$

Emissivity	e
$\frac{power\ radiated\ by\ a\ surface}{power\ radiated\ from\ a\ black\ body}$	

% Reflected

% Absorbed

Albedo vs. Emissivity



Albedo

$$\frac{60}{80} = 0.75$$

Emissivity

$$\frac{20}{80} = 0.25$$

Albedo of Earth

$$Albedo = \frac{102}{340} = 0.3$$

Albedo of Earth

Highest Albedo?

0.66

Snow

Lowest Albedo?

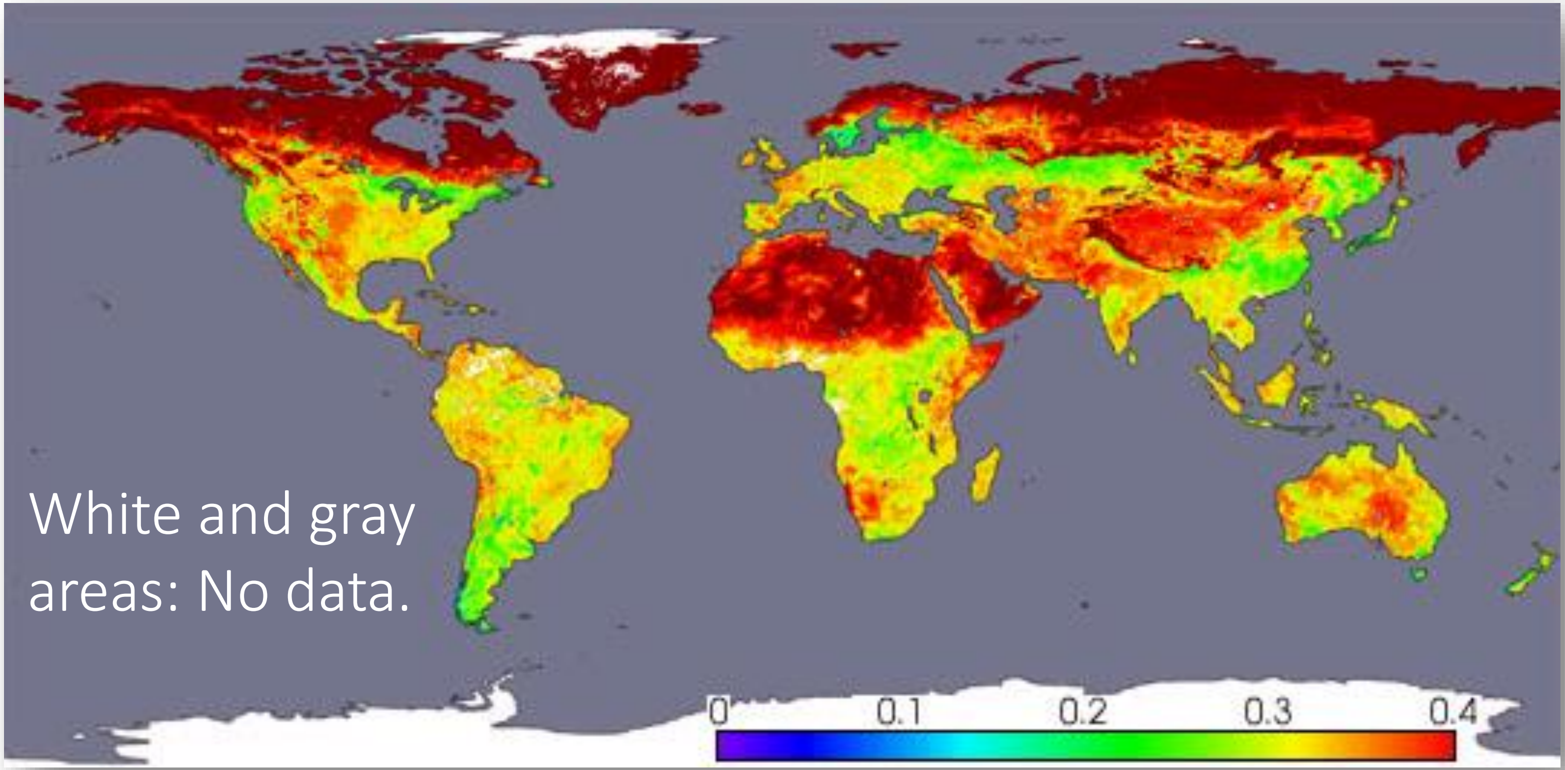
0.07

Ocean

Surface	*Albedo*[a]	
	Summer	*Winter*
Mixed farming, tall grass	0.16	0.18
Tall/medium grassland, evergreen shrubland	0.20	0.21
Short, grassland, meadow and shrubland	0.21	0.20
Evergreen forest (needle leaved)	0.12	0.13
Mixed deciduous, evergreen forest	0.16	0.16
Deciduous forest	0.17	0.18
Tropical evergreen broadleaved forest	0.12	0.15
Medium/tall grassland, woodland	0.15	0.18
Desert	0.36	0.36
Tundra	0.17	0.17
Snow	0.66	0.66
Sea ice	0.62	0.62
Ocean	0.07	0.07

Data taken from Briegleb *et al.* (1986).

Albedo of Earth



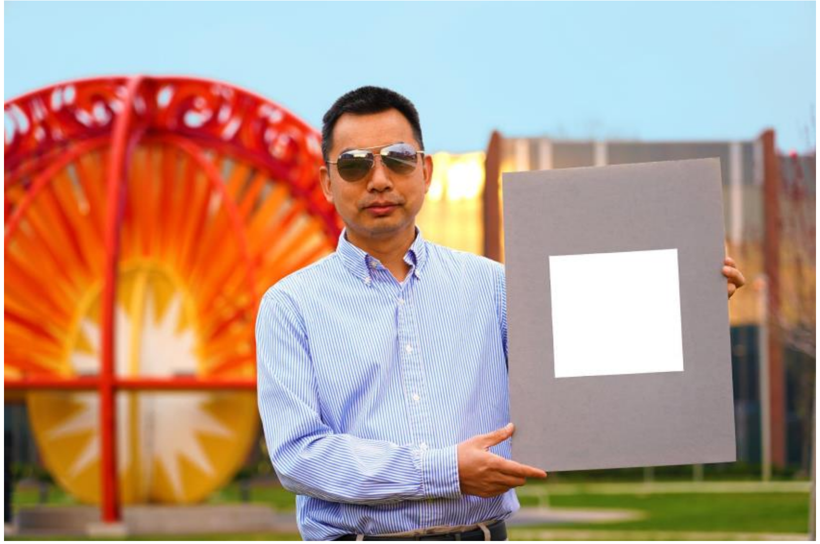
April, 2002, *Terra* satellite, NASA

Adjusting our Albedo

BUREAU OF STREET SERVICES

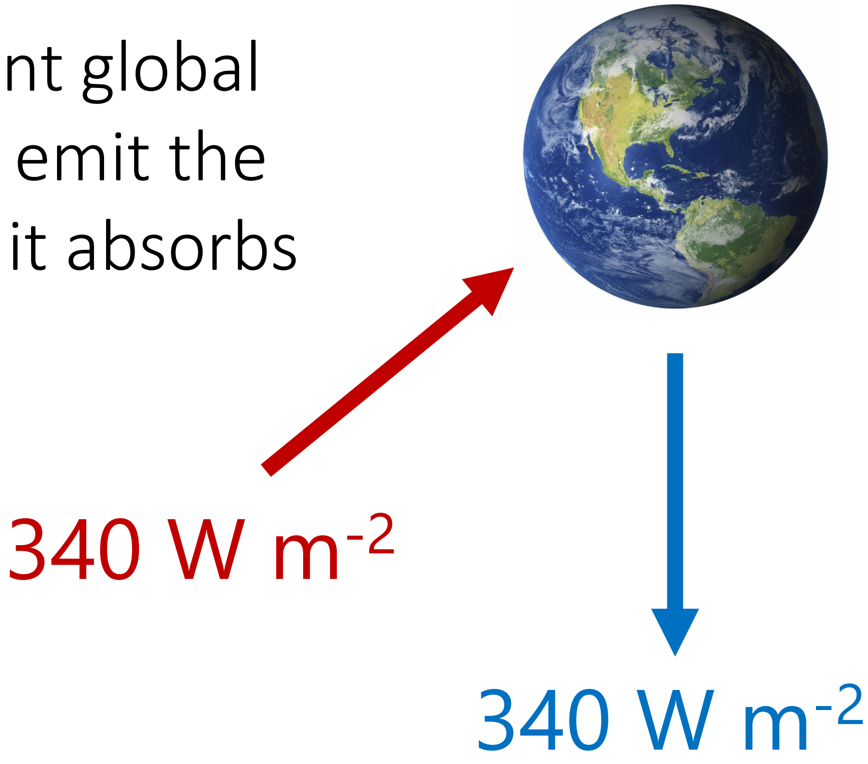
Los Angeles paints streets white to stay cool

By David Shultz | Sep. 7, 2017 , 5:00 PM



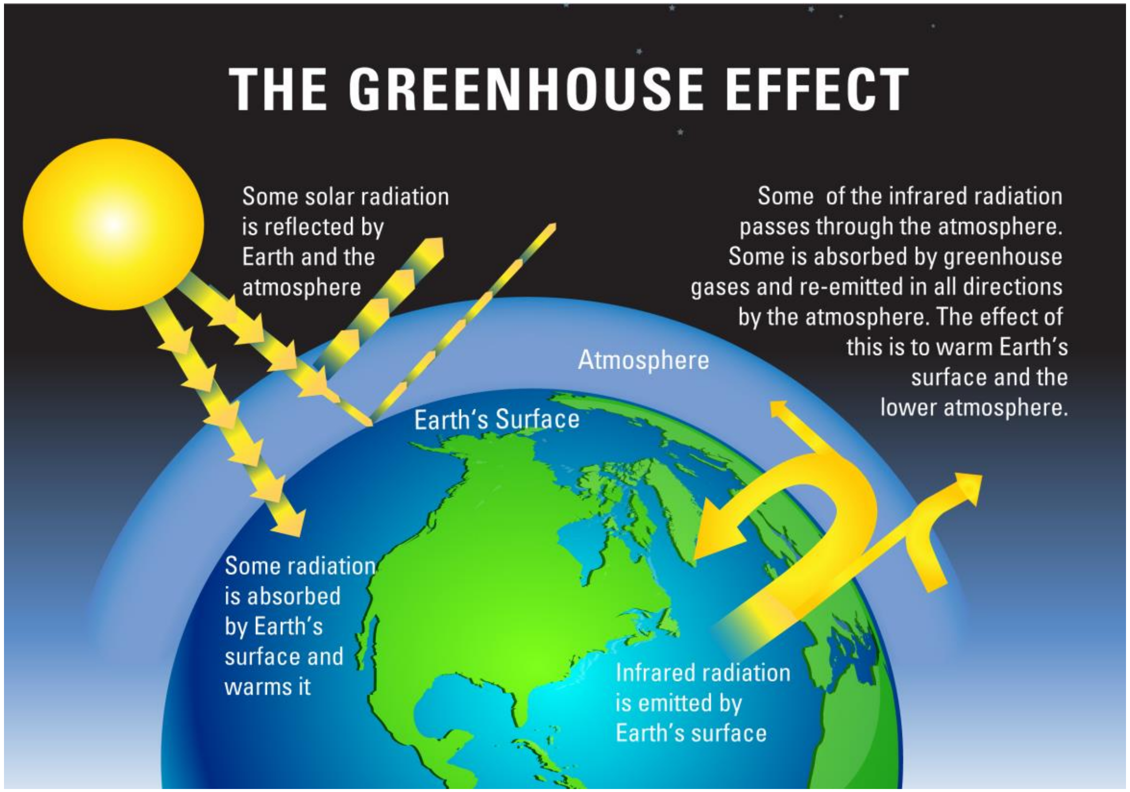
Thermal Equilibrium

In order to maintain a constant global temperature, the Earth must emit the same amount of energy that it absorbs

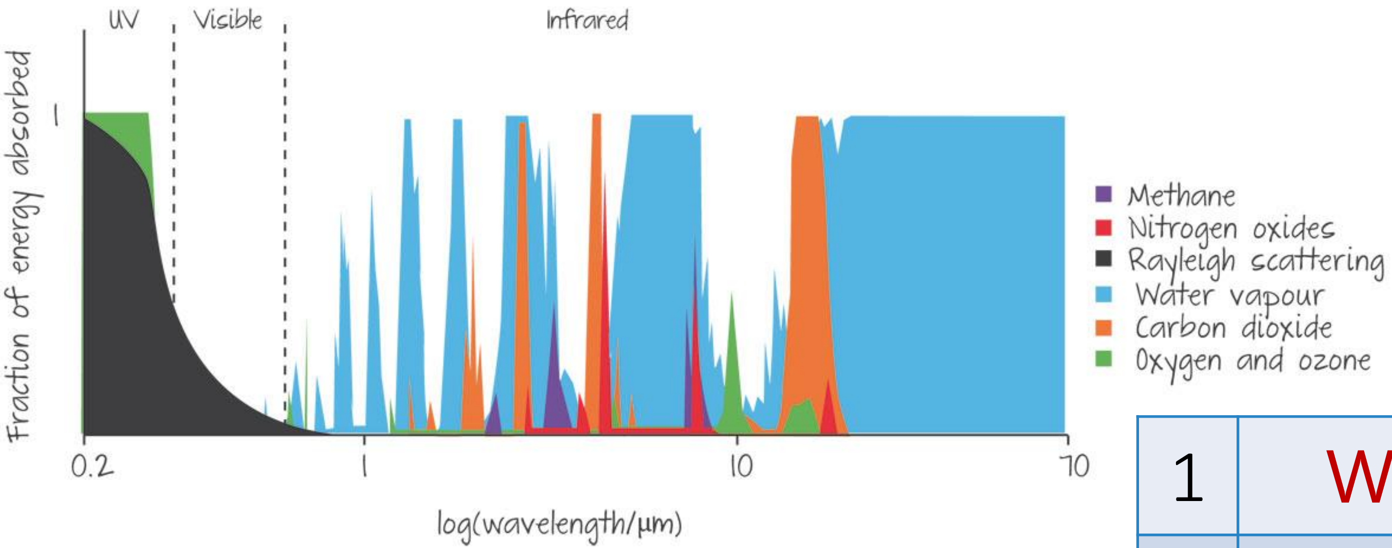


Greenhouse Effect

If there was no atmosphere, the earth would experience a net loss of energy and reach equilibrium at an average temperature about 30°C colder than it is currently.



Role of the Atmosphere



Rank the following Greenhouse Gases based on the amount of infrared energy they absorb

1	Water Vapor
2	Carbon Dioxide
3	Methane
4	Nitrogen Oxides
5	Oxygen/Ozone

More on this later…