



MUSTANSIRIYAH UNIVERSITY
COLLEGE OF SCIENCES
DEPARTMENT OF ATMOSPHERIC SCIENCES

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Solar Energy

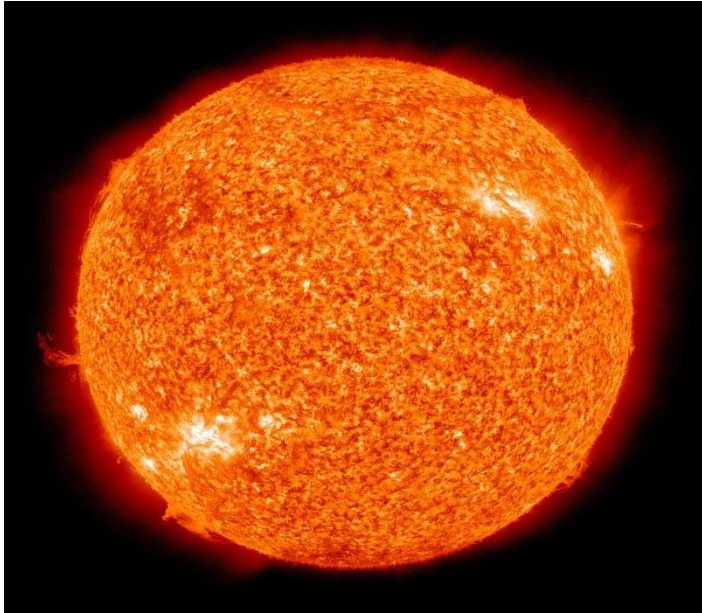
Welcome Students

TO LECTURE THREE

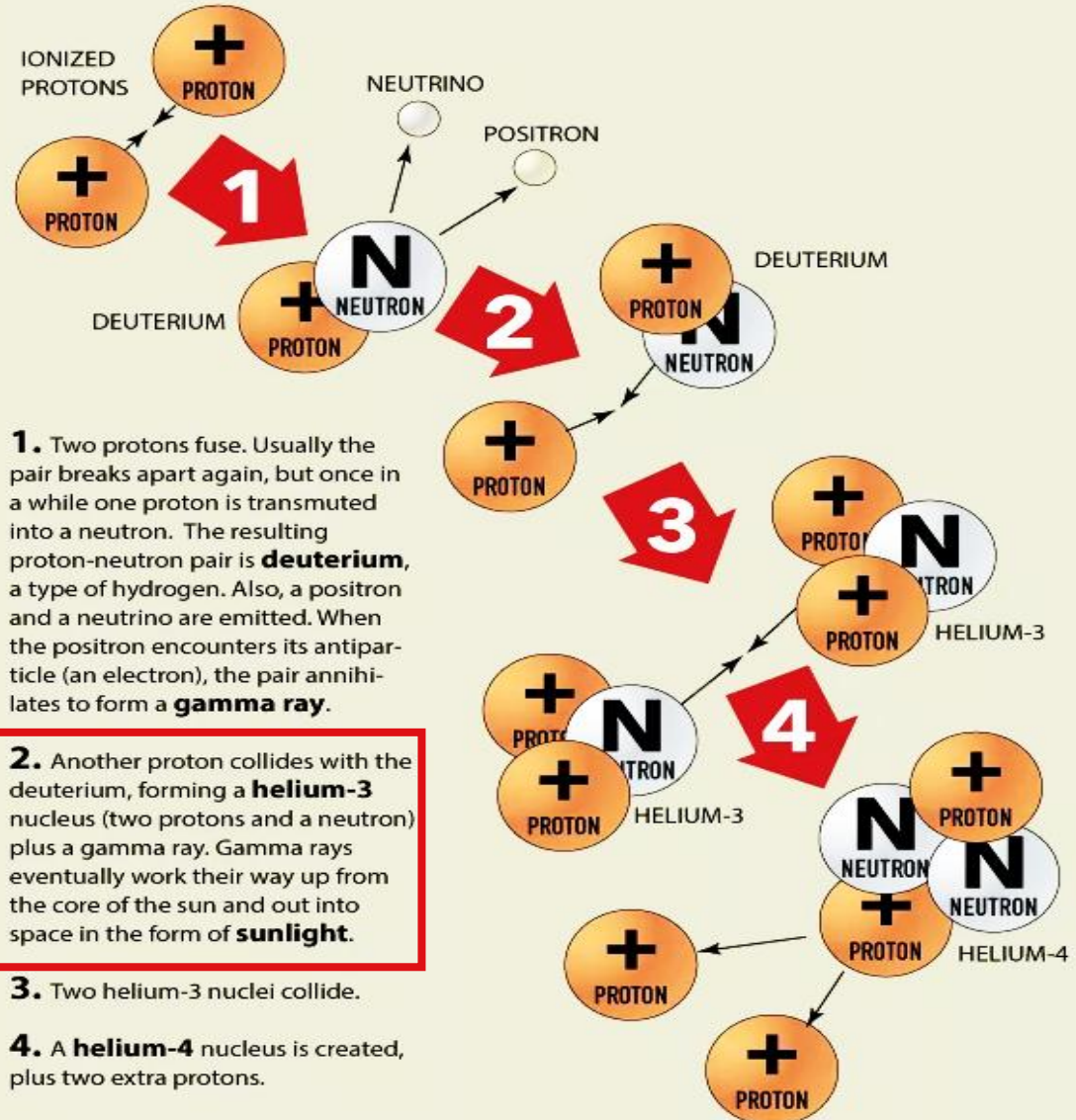


Solar Energy

THE SUN



- The sun is a star, a hot ball of glowing gases: hydrogen (92%), helium (8%).
- The temperature at the sun's core is about 15 million degrees cellulose. Surface temperature: 5500 degrees cellulose.
- By the process of fusion, protons are converted into helium nuclei plus energy.

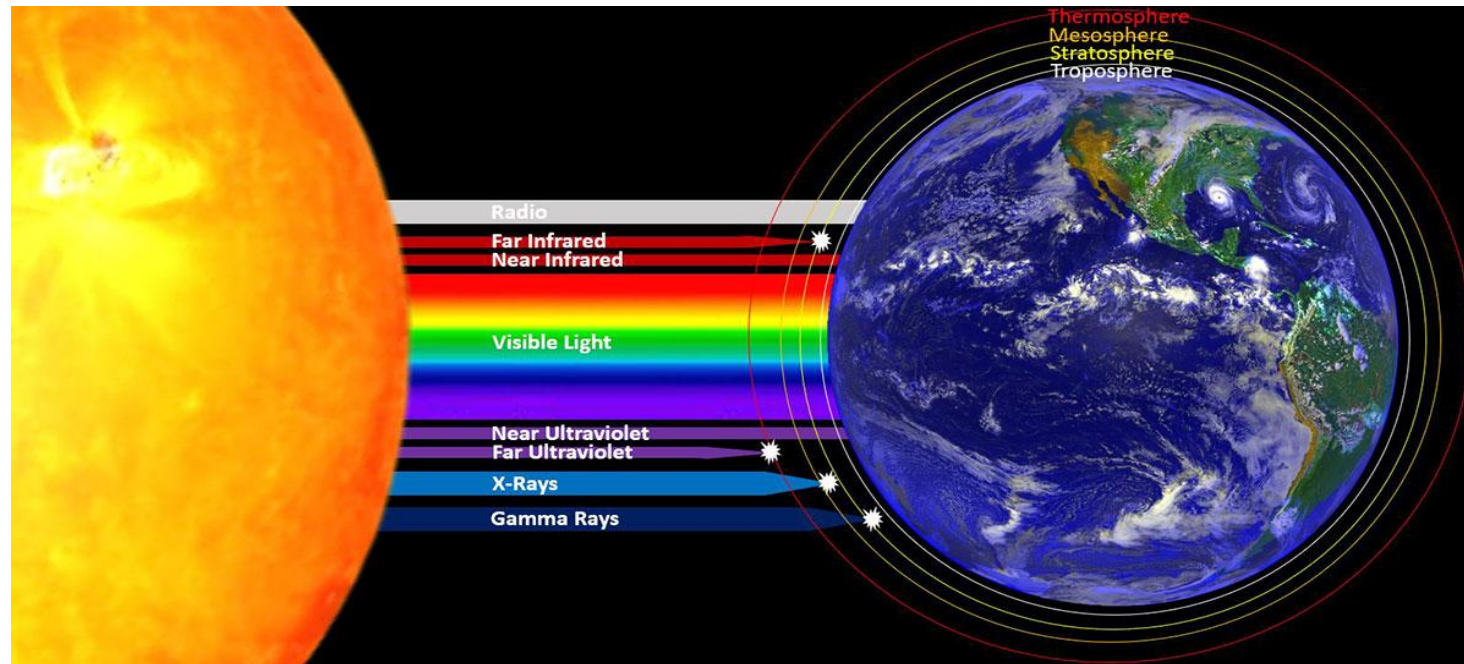




Solar Energy

Solar radiation

- Electromagnetic radiation or solar radiation: The energy which product in the core of the sun, and transmitted to its surface, and than to the space as a waves in speed of light with a power of 3.8×10^{23} kw.
- At the top of the atmosphere (at the Earth's mean distance from the Sun) the earth intercepts a small portion of the sun's power, equaled to 1.73×10^{14} kw, equivalent to 1366 ± 2 w/m².
- solar constant: The average amount of solar radiation that reaches the earth's upper atmosphere. on a surface perpendicular to the sun's rays; equal to 1367 (W/m²).
- intensity of solar radiation it is the transfer rate of the beams energy across the unit area of a body (W/m²).



Radiation is the energy transmitted by electromagnetic waves from a hot body to a colder one



Solar Energy

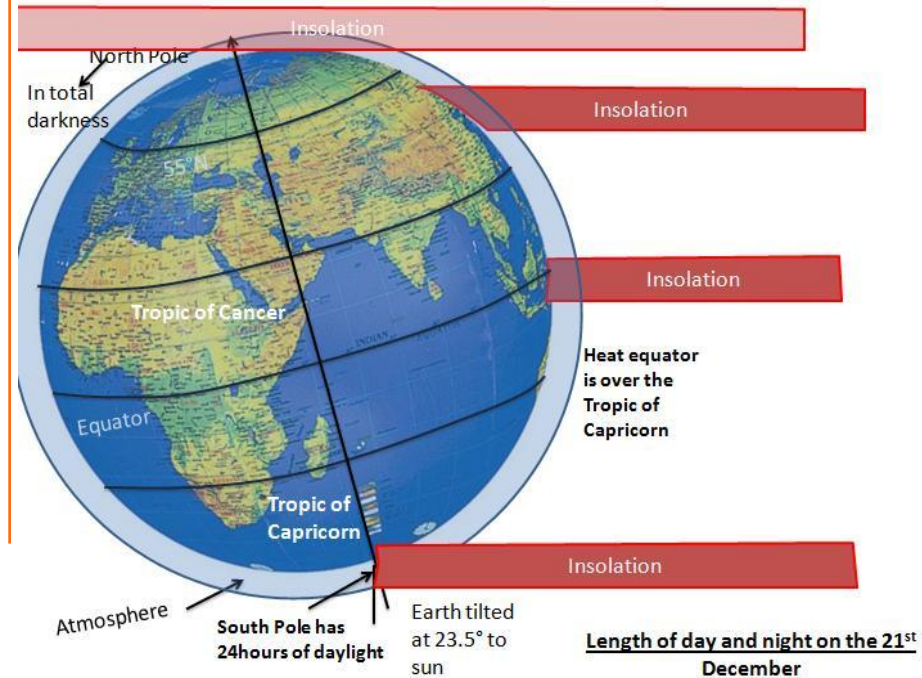
Solar radiation

- **Irradiance:** The rate of radiant energy that incident on unit area of any surface (W/m^2).
- **extraterrestrial irradiance:** irradiance at the top of the earth's atmosphere.
- **Irradiation** By integrating irradiance over a fixed time, usually an hour or a day derive the incident solar energy per unit area of surface (J/m^2).

Irradiation = insolation

- **Insolation or Irradiation:** it can be described as the incoming solar energy that reaches the Earth's atmosphere and surface, it is a measure of the solar energy that is incident on a specified area over a set period of time.
- Generally insolation is expressed two ways:
 1. unit ($\text{kWh}/\text{m}^2/\text{day}$) which represents the average amount of energy hitting an area each day.
 2. form is (W/m^2) which represents the average amount of power hitting an area over an entire year.
- **Insolation:** is obviously important for solar energy applications.

- The earth's orbit is elliptical, the sun-to-earth distance varies slightly with time of year, and the actual extraterrestrial irradiance varies by $\pm 3.4\%$ during the year.
- The Earth is tilted at an angle of 23.5° relative to the sun and this has a marked impact upon the amount of Insolation received by different places and at different times of the year.





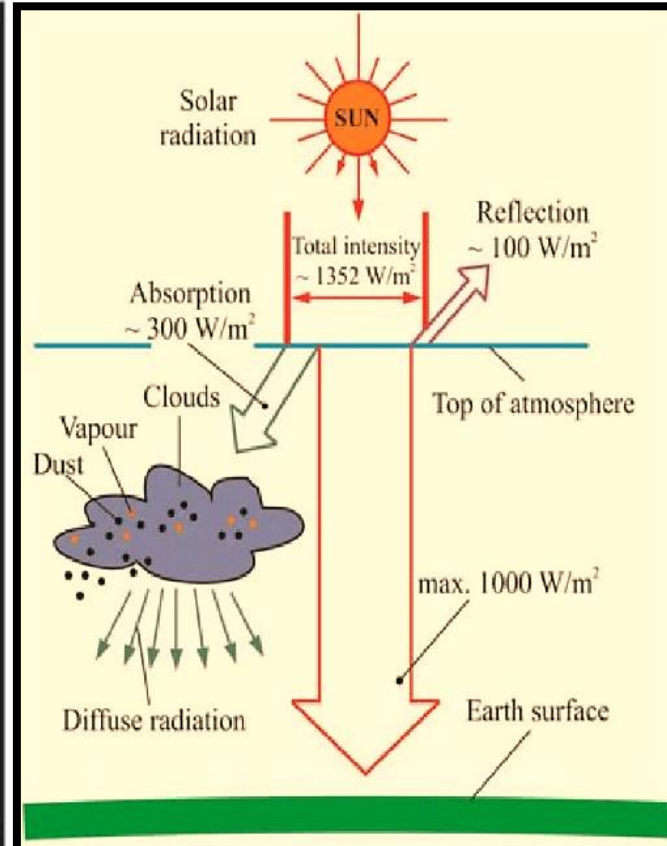
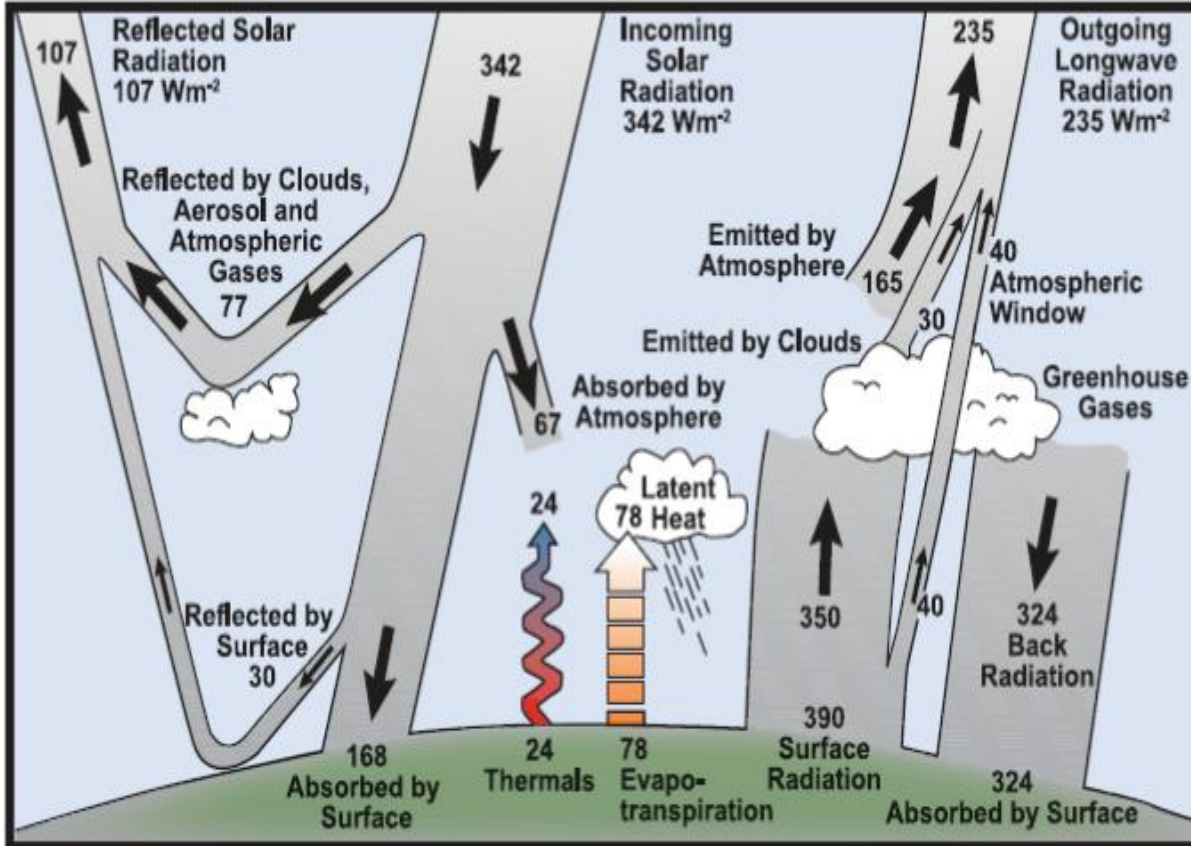
Solar Energy

Solar radiation

As sunlight = irradiation = insolation = intensity passes through the atmosphere, some of it is absorbed, scattered, and reflected by:

- 1- Air molecules
- 2- Water vapor
- 3- Clouds
- 4- Dust
- 5- Pollutants
- 6- Forest fires
- 7- Volcanoes.

At our latitude, the max. value of the solar intensity at the surface is approximately 1000 W/m² on a clear day at solar noon in the summer months.

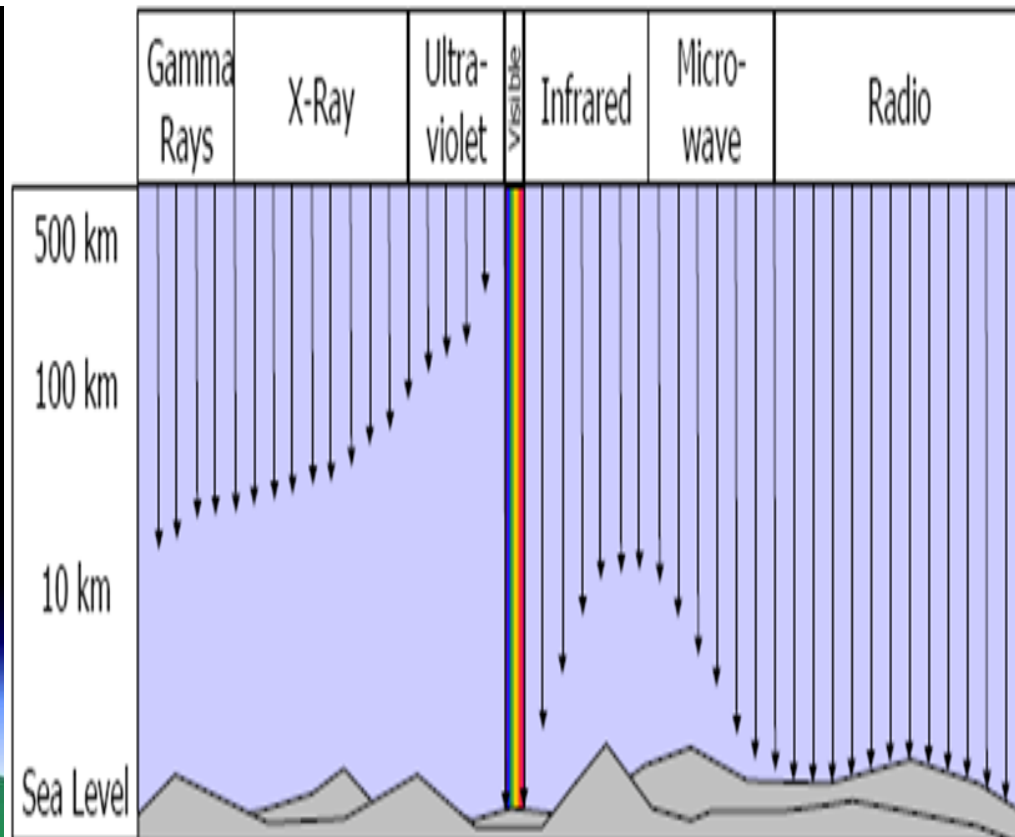
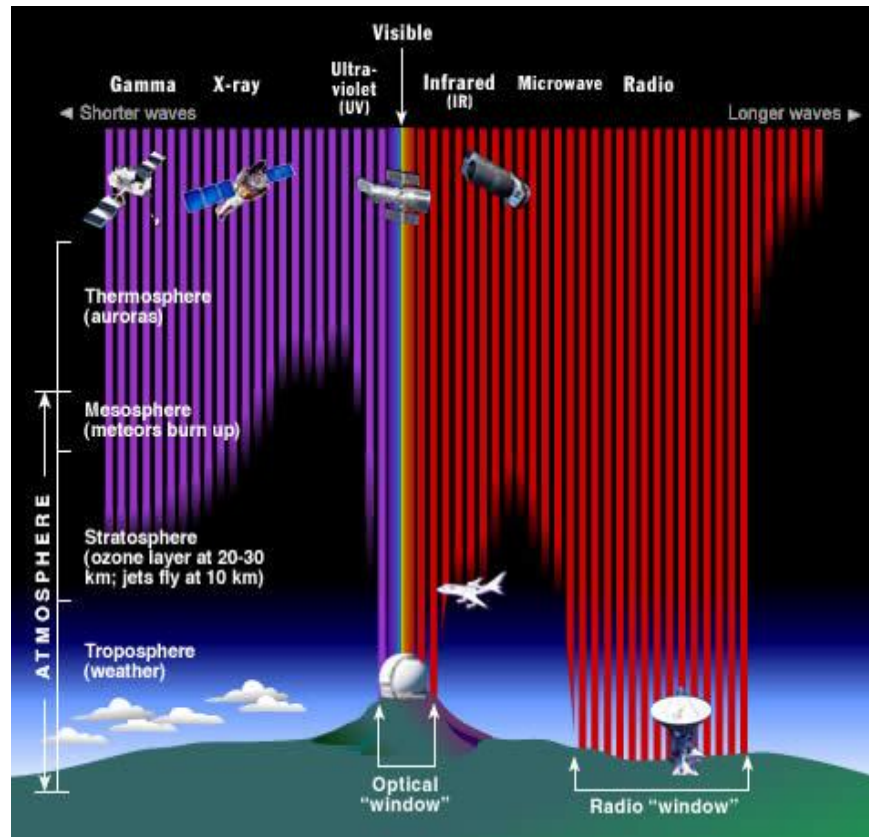




Solar Energy

Solar radiation

- When solar radiation enters the atmosphere, part of it is absorbed at the higher atmospheric layers (200-300 km altitude) where most of harmful radiation (x-ray and gamma ray).
- the rays of longer wave length is absorbed also, most of them in the ultra-violet region. Ozone layer (15-40 km altitude) protects the Globe form ultra-violet ray.
- There are anther absorbed in long wave region (infrared & micro-wave) at height less than 10 km.
- The solar radiation undergoes further attenuation by water vapor and dust suspended in air.





Solar radiation

➤ Every location on Earth receives sunlight at least part of the year. The amount of solar radiation that reaches any one spot on the Earth's surface varies according to:

- Geographic location
- Time of day
- Season
- Local landscape
- Local weather.

➤ Iraq is located in the region, which has a very good amount of solar energy with an estimated average number of hours of solar brightness **8.8 hours per day**.

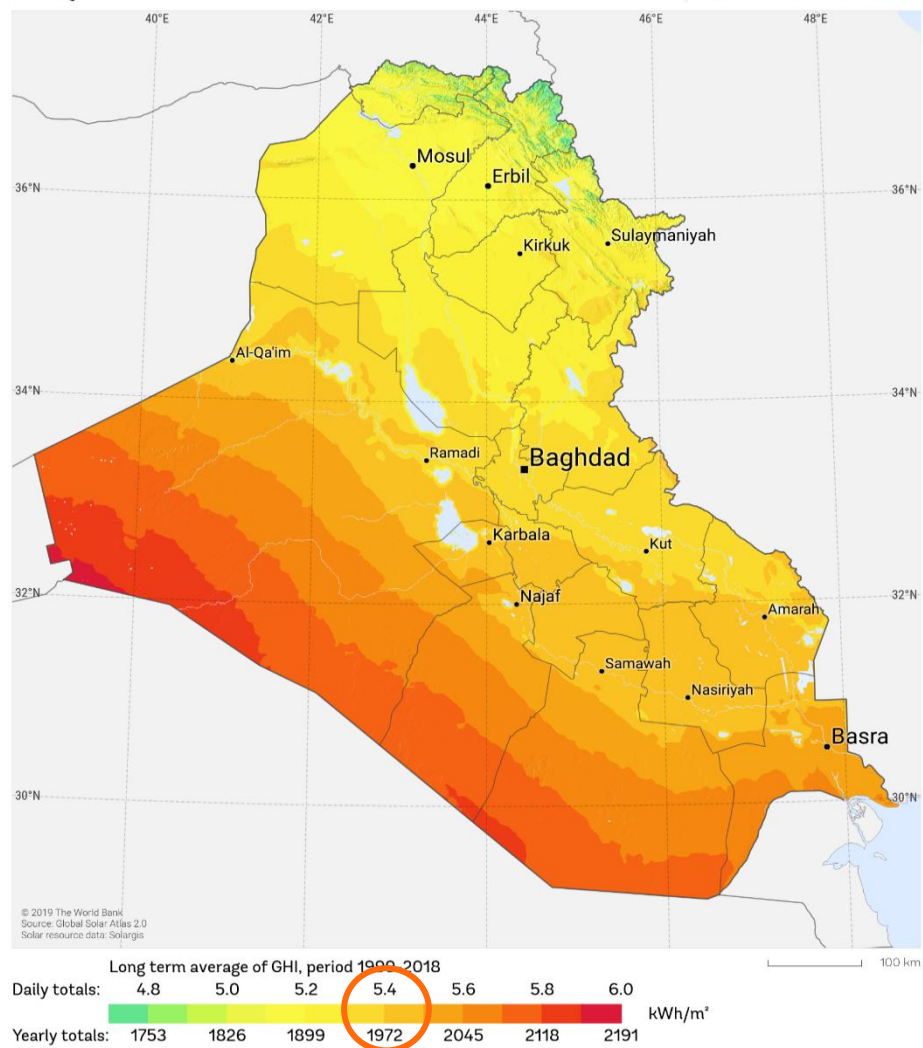
➤ the estimated average solar energy received in Iraq **539 W/m²**

Solar Energy

SOLAR RESOURCE MAP

GLOBAL HORIZONTAL IRRADIATION

IRAQ





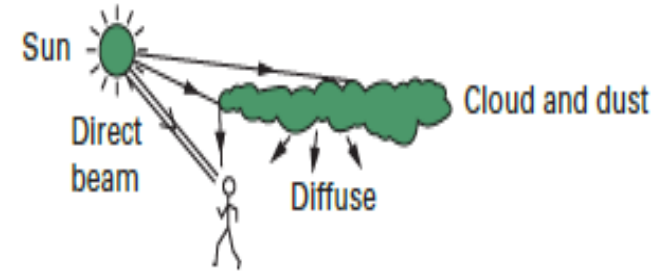
Solar Energy

Solar radiation

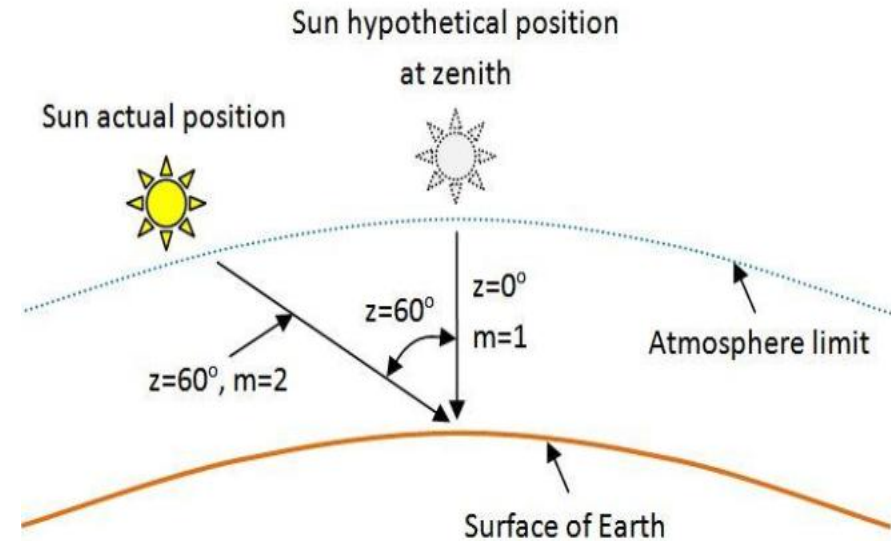
Terrestrial solar radiation intensity (Irradiance) in W/m^2 :

Solar radiation can be divided into two main parts:

- **Direct Radiation:** It is the direct solar radiation without any attenuation or diffusion.
- **Diffused Radiation:** It is the part that is re-emitted by the atmosphere in all directions.



Air Mass (m): It is a hypothetical term to measure the amount of attenuation of solar radiation by atmospheric air. Air mass is defined as the ratio of the actual distance traversed by the solar beam in the atmospheric air to the minimum hypothetical distance if sun would be at the zenith, (Accordingly air mass is related to zenith angle (z) as follows:



$$m = \frac{1}{\cos(z)} \quad 80^\circ > z \geq 0^\circ$$

Note that even on a cloudless, clear day, there is always at least 10% diffuse irradiance from molecular scattering, etc. The ratio between the beam irradiance and the total irradiance thus varies from about 0.9 on a clear day to zero on a completely overcast day.