Lecture 2

Solar Constant

Is the amount of radiation that reaches the Earth from the sun above the Earth's atmosphere, it equal to = 1382 W/m^2 and varies with season and solar activity , but when the temperature decrease to 5762 K the S.C drop to 1352 W/m^2, the value of S.C between them .

هو الكمية الإجمالية للطاقة الإشعاعية الواصلة من الشمس والساقطة عمودياً على وحدة المساحة من سطح الغلاف الجوي الخارجي للأرض عند قيمة متوسط المسافة بين الأرض والشمس . وهي كمية ليست ثابتة تماماً وإنما تتغير قليلاً حول تلك القيمة وتقدر هذه الكمية بنحو 1,35 كيلو واط على المتر المربع الواحد. وهذا المقدار الثابت من الطاقة الإشعاعية الواصلة من الشمس هو الذى يجعل الحياة ممكنة على سطح الأرض.

نتيجة للاختلاف المركزي لمدار الأرض فإن المسافة بين الشمس والأرض تختلف بحوالي 1.7% عند مسافة وحدة واحدة فلكية فإن متوسط المسافة بين الارض والشمس تقدر ب 149.5 مليون كم .
يؤدى الإشعاع المنبعث من الشمس إلى الأرض إلى توفير شدة من الإشعاع الشمسي تكون ثابتة تقريباً خارج غلاف الكرة الأرضية وهذا الثابت هو يعرف بالثابت الشمسي (Gcs) والثابت عبارة عن الطاقة المنبعثة من الشمس بالنسبة لوحدة الزمن والتي تصل إلى وحدة مساحة لسطح عمودي على اتجاه الأشعة الساقطة عند المسافة المتوسطة بين الشمس والأرض خارج غلاف الكرة الأرضية. وقد تم قياس الثابت الشمسي خارج غلاف الكرة الأرضية بواسطة سفن الفضاء والبالون والمناطيد ووجد أنه يساوى تقريبا

1352 W/m^2 مع نسبة خطأ تقدر بحوالي ± 1.5 %

The Solar Radiation

Solar radiation, often called the solar resource or just sunlight, is a general term for the electromagnetic radiation emitted by the sun. Solar radiation can be captured and turned into useful forms of energy, such as heat and electricity, using a variety of technologies. However, the technical feasibility and economical operation of these technologies at a specific location depends on the available solar resource.

BASIC PRINCIPLES

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.

DIFFUSE AND DIRECT SOLAR RADIATION

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

- Air molecules
- Water vapor
- Clouds

- Dust
- Pollutants
- Forest fires
- Volcanoes.

This is called *diffuse solar radiation*. The solar radiation that reaches the Earth's surface without being diffused is called *direct beam solar radiation*. The sum of the diffuse and direct solar radiation is called *global solar radiation*. Atmospheric conditions can reduce direct beam radiation by 10% on clear, dry days and by 100% during thick, cloudy days

The degree to which solar energy is **reduced** as it arrives at the earth's surface is determined primarily by the **optical site of our atmosphere**

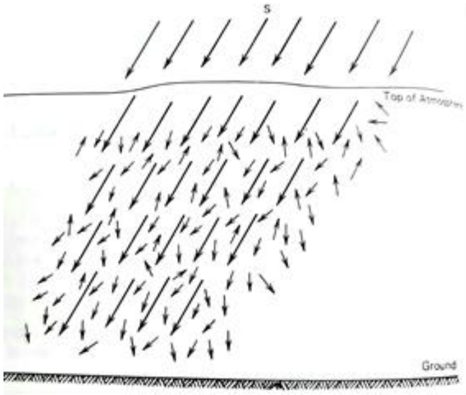
Atmospheric constituents affect solar radiation by two processes

Absorption and **scattering**

The amount of absorption and scattering **depends** on the composition on the | | Ts atmosphere and on the wavelength of that component .

Some of the radiation scattered by the atmosphere finds way to ground as Diffuse radiation .The diffuse consists of components traveling in many direction .

The total S.R at the earth's surface consists of a direct component, which not absorbed and scattered .



The Atmospheric solar flux as it penetrates the atmosphere .

The earth's surface is covered by a layer of atmosphere consisting of a mixture of gases and other solid and liquid particles. The gaseous materials extend to several hundred kilometers in altitude, though there is no well-defined boundary for the upper limit of the atmosphere.

The first 80 km of the atmosphere contains more than 99% of the total mass of the earth's atmosphere.

The vertical profile of the atmosphere is divided into four layers: troposphere, stratosphere, mesosphere and thermosphere. The tops of these layers are known as the tropopause, **stratopause**, **mesopause** and **thermopause**, respectively.

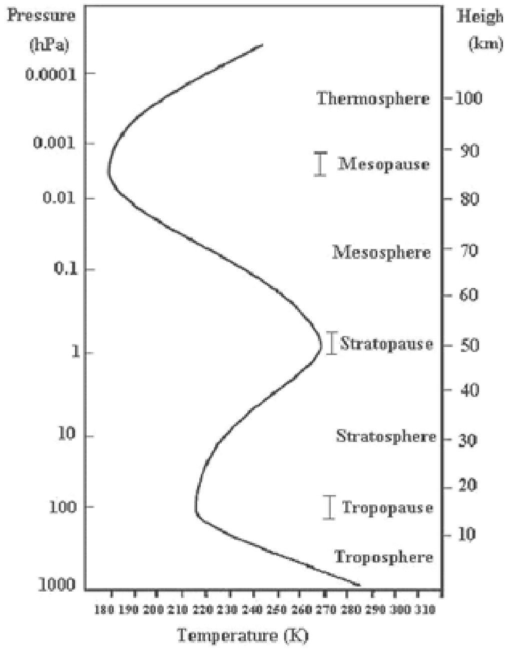
Troposphere: This layer is characterized by a decrease in temperature with respect to height, at a rate of about 6.5ºC per kilometer, up to a height of about 10 km. All the weather activities (water vapor, clouds, precipitation) are confined to this layer. A layer of aerosol particles normally exists near to the earth surface. The aerosol concentration decreases nearly exponentially with height, with a characteristic height of about 2 km.

Stratosphere: The temperature at the lower 20 km of the stratosphere is approximately constant, after which the temperature increases with height, up to an altitude of about 50 km. Ozone exists mainly at the stratopause. The troposphere and the stratosphere together account for more than 99% of the total mass of the atmosphere.

Mesosphere: The temperature decreases in this layer from an altitude of about 50 km to 85 km.

Thermosphere: This layer extends from about 85 km upward to several hundred kilometers. The temperature may range from 500 K to 2000 K. The gases exist mainly in the form of thin plasma, i.e. they are ionized due to bombardment by solar ultraviolet radiation and energetic cosmic rays.

The term upper atmosphere usually refers to the region of the atmosphere above the troposphere



Vertical Structure of the Atmosphere

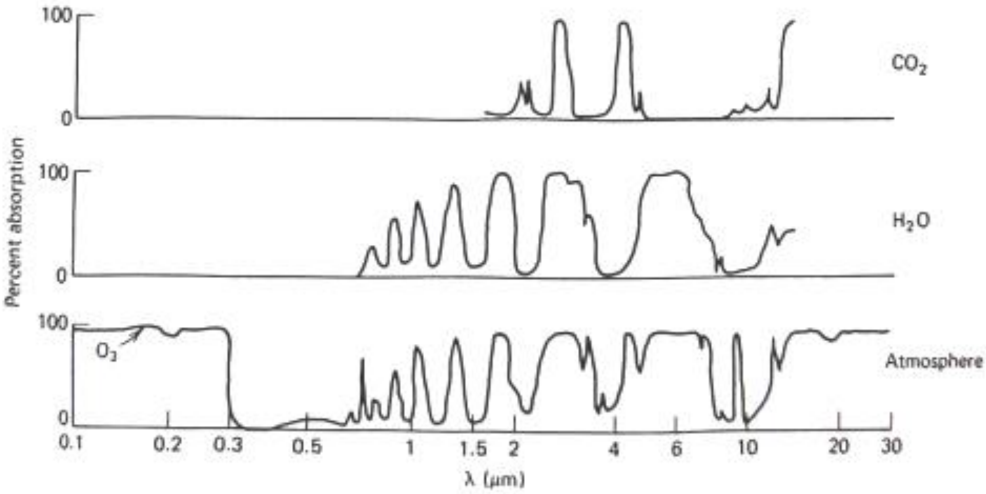
Absorption and Scattering of Solar Radiation by Atmosphere Components

affect radiation by either absorption or scattering. In absorption the radiant energy is converted into some other form, usually heat. The fraction absorbed is determined, in part, by the *mass absorption cross section*, $\sigma^a(\lambda)$, of the constituent. This parameter varies from one molecule to another and also depends on the wavelength of the incident radiation. As we will see, molecules of O_2 and N_2 do not absorb appreciably in the solar spectrum. On the other hand, CO_2 and H_2O absorb heavily in selected ranges of the infrared portion of the solar spectrum. Such regions are called characteristic absorption bands (Figure). In the ultraviolet regions of the solar spectrum, absorption bands are produced by ozone in the stratosphere.

Scattering is a more complicated process than absorption. As in absorption, a fraction of the energy is removed from the incident beam of radiation. This amount is determined by the *mass scattering cross section*, $\sigma^s(\lambda)$, of the constituent. Unlike absorption, scattering does not convert radiant energy into heat but redirects this energy into other directions of space. Atmospheric scattering of solar energy on a clear day is produced primarily by oxygen and nitrogen. Theory suggests that the scattering of solar energy by air molecules varies smoothly with wavelength according to Rayleigh's law

$$\sigma^s_{air}(\lambda) = \frac{C}{\lambda^4} \qquad \text{(Rayleigh's Law)} \qquad (3.7)$$

where C is a parameter with a slight dependence on wavelength.



The percent absorption of solar radiation by a clear atmosphere and its absorbing constituents CO_2 and H_2O.

According to Rayleigh's law, short wavelengths such as ultraviolet, violet, and blue are scattered more effectively than are red and infrared. Hence ordinary air produces substantial scattering in the visible spectrum, particularly for blue-violet components, accounting for the bluish color of the sky. Certain particles produce scattering that favors the forward and backward directions (e.g., Rayleigh scattering), whereas others scatter radiation in a more isotropic manner. Particulate matter in the atmosphere, such as dust, soot, and haze, scatters radiation in a still more complicated manner than that predicted by Rayleigh's law. Reddish sunsets result from the scattering of radiation by dust particles near the earth's surface.

The radiation that has survived scattering and absorption is called the *direct* or attenuated component. For a plane-stratified atmosphere, this component is relatively simple to compute and will be shown to be determined by a *single*, wavelength-dependent atmospheric parameter known as the *optical thickness*, τ_λ. This parameter and the way in which it affects the direction radiation will be considered in detail.

The atmosphere consists of the following components:

Permanent Gases: They are gases present in nearly constant concentration, with little spatial variation. About 78% by volume of the atmosphere is nitrogen while the life-sustaining oxygen occupies 21%. The remaining one percent consists of the inert gases, carbon dioxide and other gases**.**

- Nitrogen (N_2): 78.084% by volume
- Oxygen (O_2): 20.948%
- Argon (Ar): 0.934%
- Carbon dioxide (CO_2): 0.033%
- Other noble gases (Ne, He, Kr, Xe)
- Hydrogen (H_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Carbon monoxide (CO)

Gases with Variable Concentration: The concentration of these gases may vary greatly over space and time. They consist of water vapour, ozone, nitrogenous and sulphurous compounds.

- Water vapour (H_2O)
- Ozone (O_3)
- Sulphur dioxide (SO_2)
- Nitrogen dioxide (NO_2)
- Ammonia (NH_3)
- Nitric oxide (NO)
- Hydrogen sulphide (H_2S)

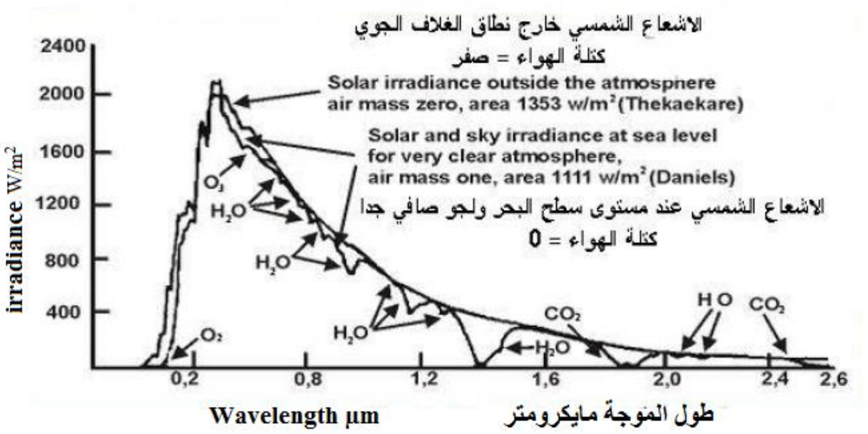
- Nitric acid vapour (HNO_3

Solid and liquid particulates: Other than the gases, the atmosphere also contains solid and liquid particles such as aerosols, water droplets and ice crystals. These particles may congregate to form clouds and haze

Depletion of solar radiation when the atmosphere is clear

استنزاف الاشعاع الشمسي في حالة صفاء الجو

When the weather is clear, the solar radiation is depleted under the following conditions:
First: It is absorbed by water vapor, oxygen molecules, ozone gas, and carbon dioxide According to certain wavelengths.
Figure shows the effects of oxygen, water vapor, carbon dioxide and other compounds The atmosphere is on the solar spectrum.



The effect of gases on the solar spectrum

Depletion of solar radiation in cloudy weather

And radiation faces another obstacle on its way to the surface of the Earth, which is **clouds**. The solar radiation and the atmosphere are cloudy as much as possible, as most of the radiation is reflected outward into space .Part of it is absorbed by the clouds and the remaining part is emitted down towards the earth in the form of radiation .Most types of clouds have good reflectivity. (diffuse radiation)
Most types of clouds have **good reflectivity.**
And low **absorption of radioactive energy**. And the ability of clouds to reflect radiation depends on the density of clouds
And on the size of cloud particles, are they drops of water or snow, and on the sizes of these particles. And that reflexivity may be less than 50% and may increase to reach 80%. It does not exceed what the "reflectivity" clouds absorb.

Of the radiation reaching it about 10% and that most of what is not reflected by clouds penetrates it.

"ρground" albedo الانعكاس وعاكسية الأرض(البيدو)

When the radiation reaches the ground, it is affected by it as well, and the surface of the earth is a poor reflector, and the reflectivity of the earth depends
From the sky as well as the global receives on the soil type. The solar collector receives the total solar radiation
Solar radiation reflected from the Earth. The amount of reflected radiation from the ground depends on a parameter
The value of the ground reflection ranges from 0.2 to 0.2, known as the albedo
Normal and 0.7 when there is snow. Table shows some of the materials that exist on Earth and their ability to

	العاكسية
معدل جميع أنواع الغيوم	50 % إلى 55 %
الخراسانة	17 % إلى 27 %
المزروعات الخضراء	5 % إلى 15 %
الغابات	5 % إلى 10 %
المراعي الخضراء	10 % إلى 20 %
حقل محروث رطب	14 % إلى 17 %
طريق اسفلت اسود	5 % إلى 10 %
رمل ابيض	34 % إلى 40 %
ثلج حديث	75 % إلى 90 %
ثلج قديم	45 % إلى 70 %
تربة داكنة	5 % إلى 15 %
تربة كالصحراء	25 % إلى 30 %
الماء	8 % ويعتمد على اتجاه الشمس