SNS COLLEGE OF ENGINEERING

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

19EE711 SOLAR AND WIND ENERGY

UNIT III-SOLAR RESOURCE

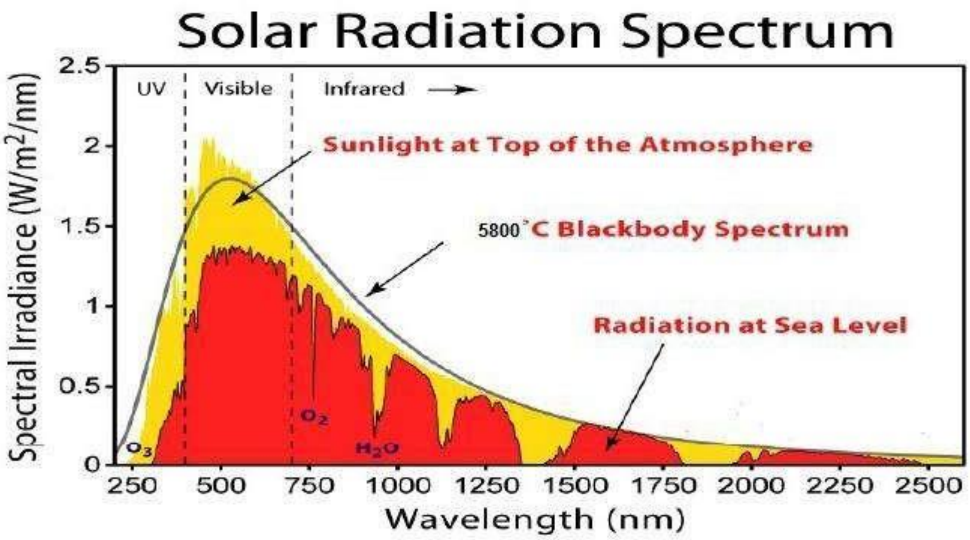
Characteristics of Solar Radiation & Radiation Spectrum

The characteristics of Solar Radiation are best explained with the help of the Solarspectrum plots which give data on intensity as spectral content. These characteristics are normally shown at ***Extra Terrestrial*** (above the atmosphere) level and at ***Terrestrial level*** (sea level) in comparison with a standard, a Black body at 5800 k. The solar spectrum typically extends from the **IR** to the **UV** region, wave - length range from 3 μm to 0.2 μm. But the intensity is not uniform. A typical solar spectrum, as a plot of spectral irradiance vs. wavelength, is shown in the figure below. The area under the curve gives the total areal intensity and this is approximately **1.35 kW/m^2**. In this context let us define a commonly used term ***'Solar Constant'***.

Solar constant: The Sun-Earth distance varies about the mean distance by around

1.7 percent. At the mean distance of **149.5 million km** which is known as one ***Astronomical Unit (AU),*** the *solar flux* outside the earth's atmosphere is 1.353 kW/m^2, which is a quantity known as the ***Solar Constant.***

The solar spectrum can be approximated by a black body radiation curve attemperature of approximately 5800^{0}C. There is also a difference in the spectra measured at the top of the atmosphere and at the surface, due to atmospheric scattering and absorption. It can also be seen that as solar radiation makes its way towards the earth's surface, some of it is absorbed by various constituents in the atmosphere, giving the terrestrial spectrum an irregular, bumpy



shape

Figure-1: Typical solar spectrum at the top of the atmosphere and at sea level. The difference is the radiation absorbed/scattered by the atmosphere. The spectrum of a black body at 5800^{0}C is also superimposed.

Also shown are the areas under the actual solar spectrum that corresponds to wavelengths within the ultraviolet UV (7%), visible (47%), and infrared IR (46%) portions of the spectrum. The visible spectrum, which lies between the UV and IR, ranges from 0.38 µm (violet) to 0.78 µm (red).

Air Mass Ratio: The terrestrial spectrum also depends on how much atmosphere the radiation has to pass through to reach the surface. As shown in the figure below, under the simple assumption of a flat earth the air mass ratio can be expressed as:

Air mass Ratio 'm' = $\frac{h2 \text{ (path length through the atmosphere with sun directly overhead)}}{h1 \text{ = (path length through the atmosphere to reach a spot on the surface)}}$

= **1/ Sin β (β** = the altitude angle of the sun as shown below)

Thus an air mass ratio of 1 (designated "AM1") means, the sun is directly overhead. By convention, AM0 means no atmosphere i.e. it is the extraterrestrial solar spectrum. Often, an air mass ratio of 1.5 is assumed for an average solar spectrum at the earth's surface.

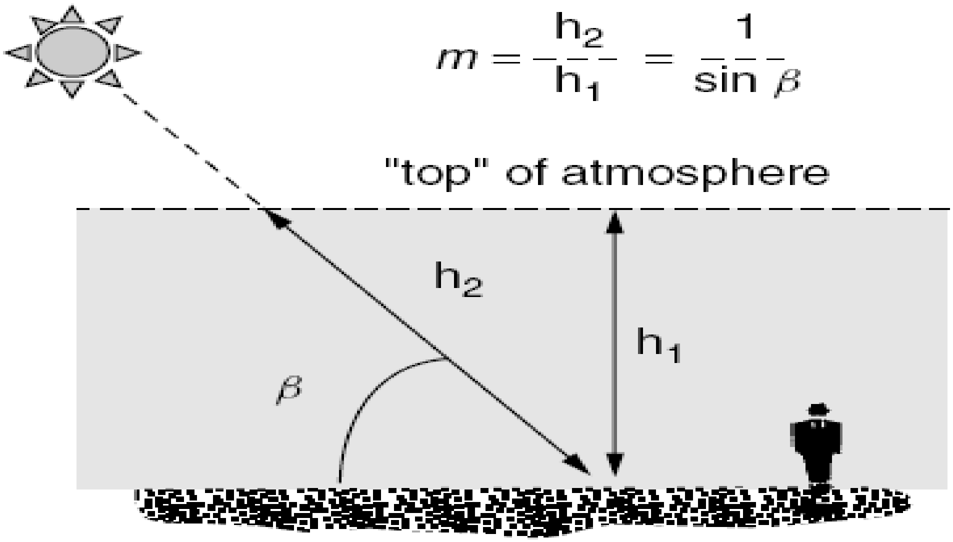
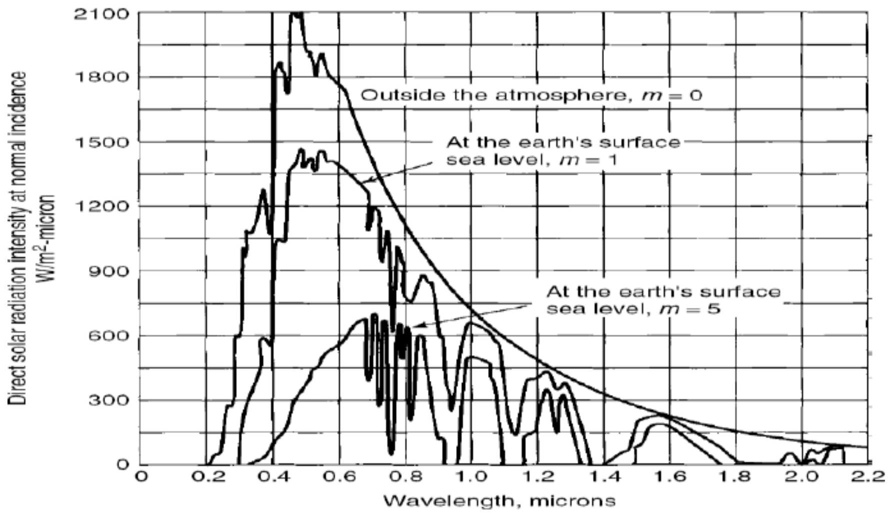


Figure-2: The air mass ratio *m* is a measure of the amount of atmosphere the sun's rays must pass through to reach the earth's surface. For the sun directlyoverhead, *m* = 1.

As sunlight passes through more and more atmosphere i.e. as the ***'air mass'*** ratio increases , less energy arrives at the earth's surface and the spectrum shiftssomewhat towards longer wavelengths.

This impact of the atmosphere on incoming solar radiation for various air



massratios is shown in the figure below.

Figure-3: Solar spectrum for extraterrestrial (m = 0), for sun directly overhead (m ***= 1), and at the surface with the sun low in the sky, m = 5.***