

## SOLAR IRRADIANCE

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Reference: Carroll, Bradley W. & Ostlie, Dale A. (2007), *An Introduction to Modern Astrophysics*, 2nd Edition; Pearson Education - Chapter 3, Problem 3.2.

The luminosity of the Sun is

$$L_S = 3.839 \times 10^{26} \text{ watts} \quad (1)$$

On a sphere of radius  $r$  centred at the Sun, the power received is therefore

$$F = \frac{L_S}{4\pi r^2} \quad (2)$$

which is the inverse square law for radiation from a spherically symmetric source. At the distance of the Earth,  $r = 1 \text{ AU} = 1.496 \times 10^{11} \text{ m}$  so the solar flux, known as the *solar irradiance*, is

$$F_S = 1365 \text{ W m}^{-2} \quad (3)$$

This is the power received when the Sun is directly overhead, which can occur only between the tropics of Cancer and Capricorn. At my latitude of around  $56^\circ \text{ N}$ , the highest the Sun can get in the sky occurs at noon on the summer solstice, when the Sun's declination is around  $+23^\circ$ , putting it at an altitude of  $(90 - 56 + 23) = 57^\circ$ . The flux here is therefore

$$F_{\text{summer}} = F_S \sin 57^\circ = 1145 \text{ W m}^{-2} \quad (4)$$

At the winter solstice, the Sun's maximum altitude is  $90 - 56 - 23 = 11^\circ$ , giving a flux of

$$F_{\text{winter}} = F_S \sin 11^\circ = 260 \text{ W m}^{-2} \quad (5)$$

I've actually measured this in my own backyard with my weather station (see the High Solar Rad graph about halfway down the page) and the numbers do check out; in June the highest recorded radiation is between 1100 and 1200 and in December it peaks at around 200.

A somewhat dated comparison is to look at the radiation emitted by an old-fashioned 100 W light bulb. In order for us to receive the solar irradiance from such a bulb, we'd need to be at a distance

$$r = \sqrt{\frac{100}{4\pi \times 1365}} = 7.6 \text{ cm} \quad (6)$$

More modern light bulbs such as LEDs emit just as much light as the old high-power bulbs but consume much less power (a typical LED consumes under 5 watts). This is because most of the energy in an LED goes into emitting light while in an old 100W bulb, a large portion of the energy is radiated as heat (or to be more precise, infrared radiation).

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