

# An Introduction to Atmospheric Radiation

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The annual global insolation is proportional to  $(1 + e^2/2)$ , but is independent of the declination of the sun  $\delta$  and the true anomaly  $\nu$ .

## 2.3 Solar Spectrum and Solar Constant Determination

### 2.3.1 Solar Spectrum

The solar spectrum covers wavelengths ranging from gamma rays to radio waves, as shown in Fig. 1.1. Because of the nonquantized electronic transitions, most solar energy is carried by the continuum, i.e., radiation is continuous rather than selective. The single most important contributor is hydrogen, both in its neutral state and as negative ions. A radiation transition from one level to another is characterized by an absorption or an emission line whose frequency is governed by Planck's relation. However, in the ionization process the atom (or molecules) may absorb more than the minimum energy required to remove the electron. This additional energy may be thought of as supplying kinetic energy to the freed electron and is not quantized. As a consequence, absorption is not selective but rather continuous. The ionization continuum occurs on the high-frequency (shorter wavelength) side of the ionization frequency. Neutral hydrogen has ionization continua associated with lines, some of which were defined in Fig. 1.9. Metallic atoms also contribute to the continuum in the ultraviolet spectrum. The continuum absorption in the visible and infrared spectrum, however, is produced by negative hydrogen ions.

Electromagnetic radiation emerging from within the sun is continuously emitted and absorbed by atoms. As shown in Fig. 2.2, the radiative temperature first drops off to a minimum value of about 4500 K just above the photosphere, and then levels off and slowly rises in the chromosphere, followed by a rapid rise in the transition region to several million degrees in the corona. At each temperature, probabilities of the electronic transition exist that any atom will achieve a particular excited state, leading to the formation of absorption lines at different levels in the solar atmosphere. The core of a line forms at the temperature where the maximum transition probabilities of an electron moving from one orbital level to another occur (see Fig. 1.8). The wings of a line form at different temperature levels because of the required transition probabilities. Each absorption line has a preferred formation region in the solar atmosphere. Those lines that absorb very little radiation are known as weak lines, which can form in narrow layers of the solar atmosphere. Some of the absorption lines in the solar atmosphere were displayed in Fig. 2.2.

In view of the preceding discussion, the solar spectrum consists of a continuous emission with a superimposed line structure. The visible and infrared spectrum of the photosphere shows absorption lines, known as the *Fraunhofer spectrum*. The strongest of these lines are produced by H, Mg, Fe, Ca, and Si, as well as singly ionized Ca and Mg. Most of the lines shorter than 1850 Å produced from the photosphere exhibit in emission. Light from the chromosphere and the corona has emission lines at all observed wavelengths.

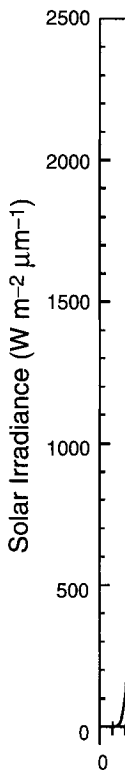


Figure 2.9 Solar Irradiance results presented in the text, based on a 5800 K accounting for

Figure 2.9 shows the solar spectrum averaged over a 5 μm band, based on the data of (Kopp and Minschwaner, 1995). Although the spectral solar constant is proposed as a 50 cm<sup>-1</sup> spectral average, the absorption produced by the atmosphere can be seen, particularly in the visible spectrum. The sun and the earth's atmosphere spectrum characteristics are used in radiative transfer