6.3.2 Diffuse Fraction Models

Available solar radiation data primarily consists of global irradiation data on a horizontal surface. Since for many applications both the diffuse and the beam components are needed the problem arises of estimating the statistical relationship between the diffuse and the global component.

The fraction of the diffuse irradiation depends, at any moment, on geographical and astronomical factors (altitude of the site, zenith angle of the sun) and on climatological factors (turbidity, amount and type of clouds, surface albedo). Due to the stochastic temporal variation of theses climatological quantities only statistical relationships can be obtained from the data. Assuming average atmospheric characteristics for a given site, which are assumed to depend only on the period of the year, a regressed relationship for the diffuse irradiation versus the global one can be derived.

The most common approach for decomposing the global radiation into their diffuse and global components is a model which relates the diffuse fraction to the clearness index:

$$\frac{G_d}{G} = f(k_t). \tag{6.10}$$

Typically, the empirical expressions for the diffuse fraction vary with the time interval under consideration (hourly, daily, monthly). For a given time period the relations are very similar despite being based on independent data.

Regressions of G_d/G vs k_t presented by Liu and Jordan in the 60s have been the main references for many years for deducing the daily and monthly diffuse irradiation from the corresponding global irradiation. Their analyses showed that these regressions are widely independent on location.

In recent years several investigations have been presented which showed a significant dependency on location and atmospheric condition.

Figure: Fraction of hourly diffuse radiation (G_d/G) as a function of the hourly clearness index k_t.

J.F. Orgill and K.G. Hollands (1977). Correlation equation for hourly diffuse radiation on a horizontal surface. *Solar Energy*, **19**, 357-359.

M. Collares-Pereira and A. Rabl (1979). The average distribution of solar radiation correlations between diffuse and hemispherical and betwen daily and hourly insolation values. *Solar Energy*, **22**, 155-164.

D.G. Erbs, S.A. Klein and J.A. Duffie (1982). Estimation of the diffuse radiation fraction for hourly, daily and monthly-average global radiation. *Solar Energy*, **28**, 293-304.

D.T. Reindl, W.A. Beckman and J.A. Duffie (1990). Diffuse fraction correlations. *Solar Energy*, **45** 1-7.

A. Skartveit and J.A. Olseth (1987). A model for the diffuse fraction of hourly global radiation *Solar Energy*, **38** 271-274.

Collares-Pereira and Rabl presented the following relations for daily data:

$$\frac{H_d}{H} = \begin{cases} 0.99 & \text{for } K_t \leq 0.17 \\ 1.188 - 2.272K_t + 9.473K_t^2 & \text{for } 0.17 < K_t \leq 0.75 \\ \quad -21.865K_t^3 + 14.648K_t^4 & \\ -0.54K_t + 0.632 & \text{for } 0.75 < K_t < 0.80 \\ 0.2 & \text{for } K_t \geq 0.80 \end{cases}$$

Earth Sun Geometry: video

https://www.youtube.com/watch?v=rnM1hXJf4WU&t=835s