the atmosphere and on the zenith angle of the sun. The increase in diffuse radiance near the horizon is due to the albedo radiation of the Earth and is called *horizon brightening*.

The radiance distributions associated with overcast skies are very well described by Kondratyev: "*for dense non-transparent cloudiness, the azimuthal dependence of diffuse radiation intensity is very weak. There is a slight monotonic increase of the radiance from the horizon upward towards the zenith*" [27].

Some models can be derived from these general ideas. The simplest model makes use of the assumption that the sky radiance is isotropic, that is, every point of the celestial sphere emits light with equal radiance, $L(\theta_Z, \psi) = \text{constant}$. The solution of equations (20.30 and 20.31) leads then to

$$D(\beta, \alpha) = D(0)\frac{1 + \cos\beta}{2} \tag{20.32}$$

Because of its simplicity, this model has achieved great popularity, despite the fact that it systematically underestimates diffuse irradiance on surfaces tilted to the equator.

The opposite approach assumes that all the diffuse radiation is circumsolar, that is, from the sun. This is really a case of treating diffuse radiation as though it were direct, and leads to

$$D(\beta, \alpha) = \frac{D(0)}{\cos\theta_{ZS}} \max(0, \cos\theta_S) \tag{20.33}$$

This model also has the advantage of being very simple to use, but in general it overestimates diffuse irradiances.

In general, better results are obtained with so called anisotropic models. Hay and Davies [28] proposed to consider the diffuse radiation as composed by a circumsolar component coming directly from the direction of the sun, and an isotropic component coming from the entire celestial hemisphere. Both components are weighted according to the so-called anisotropy index, k_1, defined as

$$k_1 = \frac{B(0)}{B_0(0)} = \frac{B}{B_0\varepsilon_0} \tag{20.34}$$

The solution of equation (20.31) is now

$$D(\beta, \alpha) = D^I(\beta, \alpha) + D^C(\beta, \alpha) \tag{20.35}$$

where

$$D^I(\beta, \alpha) = D(0)(1 - k_1)\frac{1 + \cos\beta}{2} \tag{20.36}$$

and

$$D^C(\beta, \alpha) = \frac{D(0)k_1}{\cos\theta_{ZS}} \max(o, \cos\theta_S) \tag{20.37}$$

respectively, define the contribution of the isotropic and of the circumsolar components.