$\cos(\theta) = \sin(\delta)\sin\varphi\cos(\beta) - \sin(\delta)\cos(\varphi)\sin(\beta)\cos(\gamma) + \cos(\delta)\cos(\varphi)\cos(\beta)\cos(\omega) + \cos(\delta)\sin(\varphi)\sin(\beta)\cos(\gamma)\cos(\omega) + \cos(\delta)\sin(\beta)\sin(\gamma)\sin(\omega)$ (3)

For horizontal surface β=0. Thus,

$$\cos(\theta) = \cos(\delta)\cos(\varphi)\cos(\omega) + \sin(\delta)\sin(\varphi) \quad (4)$$

$$\sin(\alpha) = \cos(\delta)\cos(\varphi)\cos(\omega) + \sin(\delta)\sin(\varphi) \quad (5)$$

$$\tan(\gamma_s) = \frac{\sin(\omega)}{\sin(\varphi)*\cos(\omega) - \cos(\varphi)*\tan(\delta)} \quad (6)$$

$$\omega_o = \cos^{-1}[-\tan(\varphi)\tan(\delta)] \quad (7)$$

$$\text{It } N = \frac{2}{15}\cos^{-1}[-\tan(\varphi)\tan(\delta)] \quad (8)$$

$$H_o(J/m^2) = \frac{86400}{\pi} Isc\left[1 + 0.033\cos\left(\frac{360\ ND}{365}\right)\right] * (\cos\varphi\cos\delta\sin\omega_o + \omega_o * \sin\varphi\sin\delta) \quad (9)$$

$$\frac{\overline{H_g}}{\overline{H_o}} = a + b\left(\frac{\bar{n}}{\bar{N}}\right) \quad (10)$$

a = 0.25 and b = 0.5 are recommended and applicable anywhere in the world **[20].**

$$H_d = H_g(1.354 - 1.57\,\overline{K_T}) \quad (11)$$

$$H_b = H_g - H_d \quad (12)$$

$$\frac{H_T}{H_g} = \left(1 - \frac{H_d}{H_g}\right)R_b + \frac{H_d}{H_g}R_d + R_r \quad (13)$$

For south facing surface, $\gamma = 0^o$

$$R_b = \frac{\omega_{st}\sin\delta\sin(\emptyset - \beta) + \cos\delta\cos\omega_{st}\cos(\emptyset - \beta)}{\omega_s\sin\delta\sin\emptyset + \cos\delta\cos\omega_s\cos\emptyset} \quad (14)$$

$$R_d = \frac{1 + \cos\beta}{2} \quad (15)$$

$$R_r = \rho\left(\frac{1 - \cos\beta}{2}\right) \quad (16)$$