TABLE OF CONSTANTS

CONSTANT	SYMBOL	VALUE
speed of light in a vacuum	c	3.00×10^{8} m s^{-1}
gravitational constant	G	6.673×10^{-11} N m^{2} kg^{-2}
orbital constant	$G\,M_E$	3.986×10^{14} m^{3} s^{-2}
standard gravitational acceleration	g	9.81 m s^{-1}
Planck's constant	h	6.626×10^{-34} J s
Boltzmann's constant	k	1.381×10^{-23} J K^{-1}
first radiation constant	c_1	1.191×10^{-16} W m^{2} sr^{-1}
second radiation constant	c_2	1.439×10^{-2} m K
Stefan-Boltzmann constant	σ	5.670×10^{-8} W m^{-2} K^{-4}
Wien's displacement law constant	none	2.8979×10^{-3} m K
Avogadro's number	N_A	6.022×10^{23} molecules mole^{-1}
Dobson unit	DU	1 DU = 2.687×10^{16} molecules/cm^{2}
molar gas constant	R	8.3143 J mole^{-1} K^{-1}
angular velocity of Earth	$d\Omega_E$ / dt	7.292×10^{-5} rad s^{-1}
solar day	T_{solar}	86,400 s
sidereal day	$T_{sidereal}$	86,164.1 s
mean radius of Earth	R_E	6.371×10^{6} m
mass of Earth	M_E	5.9737×10^{24} kg
standard pressure	p_o	1013.25 mbar = 1.01325×10^{5} N m^{-2}
standard temperature	T_o	273.15 K
scale height of Earth's atmosphere	$H = RT/Mg$	~ 7 km
radius of Sun (visible disk)	R_{sun}	6.96×10^{8} m
mean Earth-Sun distance	d_{sun}	1.50×10^{11} m
solar constant	S_{sun}	1368 W m^{-2}
molecular mass of CO_2	M	44 g/mole = 7.3065×10^{-26} kg/molecule
molecular mass of H_2O	M	18 g/mole = 2.9890×10^{-26} kg/molecule
molecular mass of O_2	M	32 g/mole = 5.3138×10^{-26} kg/molecule

LIST OF EQUATIONS – 1 of 2

$$F = \frac{Gm_1 m_2}{r^2} \qquad T = 2\pi\sqrt{\frac{r^3}{Gm_E}} \qquad v = \sqrt{Gm_E\left(\frac{2}{r} - \frac{1}{a}\right)} \qquad r = \frac{a(1-\varepsilon^2)}{1+\varepsilon\cos\theta}$$

$$M = e - \varepsilon \sin e = n(t - t_p) \qquad \cos\theta = \frac{\cos e - \varepsilon}{1 - \varepsilon\cos e} \qquad \cos e = \frac{\cos\theta + \varepsilon}{1+\varepsilon\cos\theta} \qquad \tilde{T} = \frac{2\pi}{\bar{n} + \frac{d\omega}{dt}}$$

$$LT = UT + \frac{\psi}{15^\circ} \qquad ECT = UT + \frac{\psi_N}{15^\circ} = 12 + \frac{\Delta\psi}{15^\circ} \qquad \vec{\mathbf{S}} = c^2\varepsilon_0 \vec{\mathbf{E}} \times \vec{\mathbf{H}}$$

$$I = \int_0^\infty I_\lambda d\lambda = \int_0^\infty I_\nu d\nu = \int_0^\infty I_{\bar{\nu}} d\bar{\nu} \qquad B_\lambda = \frac{2hc^2\lambda^{-5}}{\exp\left(\frac{hc}{\lambda kT}\right) - 1} = \frac{c_1\lambda^{-5}}{\exp\left(\frac{c_2}{\lambda T}\right) - 1}$$

$$\lambda_{max}(\mu m) = \frac{2897.9}{T(K)} \qquad M_{BB} = \sigma T^4 \qquad B_\lambda \cong \frac{c_1 T}{c_2 \lambda^4} \qquad \alpha_\lambda + R_\lambda + \tau_\lambda = 1 \qquad \alpha_\lambda = \varepsilon_\lambda$$

$$dI_\lambda = -\sigma_a(\lambda) I_\lambda ds = -\rho k_a(\lambda) I_\lambda ds = -k_a(\lambda) I_\lambda du$$

$$\tau_\lambda(z_1, z_2) = \exp\left[-\int_{z_1}^{z_2} \frac{k_a(\lambda)\rho}{\mu} dz\right] = \exp\left[-\int_{u_1}^{u_2} k_a(\lambda) du\right]$$

$$\frac{\mu}{\rho k_e(\lambda)} \frac{dI_\lambda}{dz} = -I_\lambda(\theta,\phi) + \tilde{\alpha}_\lambda B_\lambda(T) + \tilde{\omega}_\lambda < I_\lambda' > \qquad < I_\lambda' >= \frac{1}{4\pi}\int_0^{2\pi}\int_{-1}^{1} I_\lambda(\mu', \phi') p(\psi_S) d\mu' d\phi'$$

$$\tilde{\alpha}_\lambda = \frac{\sigma_a(\lambda)}{\sigma_e(\lambda)} \qquad \tilde{\omega}_\lambda = \frac{\sigma_s(\lambda)}{\sigma_e(\lambda)} \qquad \frac{\mu}{\rho k_e(\lambda)} \frac{dI_\lambda}{dz} = -I_\lambda(\mu,\phi) + B_\lambda(T)$$

$$k_a^L = \frac{S}{\pi} \frac{\alpha_L}{(\bar{\nu} - \bar{\nu}_o)^2 + \alpha_L^{\,2}} \qquad \alpha_L(T,p) = \alpha_L(T_o, p_o)\frac{p}{p_o}\sqrt{\frac{T_o}{T}}$$

$$k_a^D = \frac{S}{\alpha_D\sqrt{\pi}} \exp\left[-\frac{(\bar{\nu} - \bar{\nu}_o)^2}{\alpha_D^{\,2}}\right] \qquad \alpha_D(T, \bar{\nu}_o) = \sqrt{\frac{2kT}{M}}\,\frac{\bar{\nu}_o}{c}$$

$$\chi = \frac{2\pi r}{\lambda} \qquad Q_s = \frac{k_s}{\pi r^2} \qquad \sigma_s = \int_0^\infty \pi r^2 Q_s N(r) dr \qquad \sigma_s(\lambda) \cong \frac{8\pi^3}{3\lambda^4}\frac{\left[n_o(\lambda)^2 - 1\right]^2}{N_s^{\,2}} f(\delta)$$

$$m = n - i\,n' \qquad I_r(\theta_r, \varphi_r) = \int_0^{2\pi}\int_0^{\pi/2} I_i(\theta_i, \varphi_i)\gamma_r(\theta_r, \varphi_r; \theta_i, \varphi_i)\cos\theta_i \sin\theta_i d\theta_i d\varphi_i$$

$$\gamma_r(\theta_r, \phi_r; \theta_{sun}, \phi_{sun}) = \frac{I_r(\theta_r, \phi_r)}{I_{sun}\Omega_{sun}\cos\theta_{sun}} = \frac{I_r}{E_{sun}}$$

$$A = \frac{M}{E} = \int_0^{2\pi} \gamma_r(\theta_r, \varphi_r; \theta_{sun}, \varphi_{sun})\cos\theta_r d\Omega_r$$

$$I_\lambda(z_{sat}) = I_\lambda(0)\tau(0, z_{sat}) + \int_{\tau(0,,z_{sa})}^{\tau=1} B_\lambda(T) d\tau_\lambda = I_\lambda(0)\tau(0, z_{sat}) + \int_{surface}^{satellite} B_\lambda(T) K_\lambda(y) dy$$

LIST OF EQUATIONS – 2 of 2

$$dp = -g\rho_{air}\,dz \qquad \rho(z) = \frac{Mp(z)}{RT} \qquad p(z) = p(z_o)\exp\left[-\frac{(z - z_o)}{H}\right]$$

$$I_\lambda(z_{tangent}) = \int_{-\infty}^{\infty} B_\lambda[T(x)]\frac{d\tau_\lambda(x, z_{tangent})}{dx}dx \qquad B_i(T_i^{k+1}) = B_i(T_i^k)\frac{\tilde{I}_i}{I_i^k(T_i^k)}$$

$$B_i(T_{ij}^{k+1}) = B_i(T_j^k) + \left[\tilde{I}_i - I_i^k(T_j^k)\right] \qquad \mathbf{y} = F(\mathbf{x}, \mathbf{b}) + \varepsilon$$

$$\hat{\mathbf{x}} = \mathbf{x}_o + \mathbf{S}_o\mathbf{K}^T(\mathbf{K}\mathbf{S}_o\mathbf{K}^T + \mathbf{S}_y)^{-1}(\mathbf{y} - \mathbf{K}\mathbf{x}_o) \qquad \mathbf{A} = \frac{dT}{d\mathbf{x}} = \frac{dI}{d\mathbf{y}}\frac{dF}{d\mathbf{x}} = \mathbf{DK}$$

$$I_\lambda = E_{sun}(\lambda)[\tau_{ozone}(\lambda)]^x R(\theta_{sun}, \theta_{satellite}; R_{surface}, R_{air})$$

$$N(\lambda) = -100\log_{10}\left[\frac{I(\lambda)}{E_{sun}(\lambda)}\right] = -100\log_{10}\left[R(\lambda)\exp\{-k_a(\lambda)Ux\}\right]$$

$$\tau_\lambda(h_i) = \frac{I_\lambda(h_i)}{I_\lambda^{\,o}} = \exp\left[-\int_{-\infty}^{\infty}\sigma_{e,\lambda}(s)ds\right]$$

$$I(\lambda, z_{tan}) = E_o(\lambda)\int_{l-o-s}\tau_{in}(\lambda, \infty : z)S(\lambda, z, \theta)\tau_{out}(\lambda, z : \infty)dz$$

$$I(\lambda) = (1 - N)I_{clear}(\lambda) + N\varepsilon I_{cloud}(\lambda) + N(1 - \varepsilon)I_{clear}(\lambda)$$

$$k_L U_L + k_V U_V = -\frac{\mu}{2}\ln\left[\frac{T_o - T_B}{\{1 - \varepsilon(\mu)\}T_o}\right]$$

$$I_{aerosol} \cong \frac{\tilde{\omega}_o}{4\pi}E_{sun}\,p(\psi_{sun})\frac{1}{\mu}\int_{surface}^{satellite}\sigma_{aerosol}\,dz$$

$$P_r(\lambda, R) = P_t(\lambda)C(\lambda)\frac{\Delta R}{R^2}\frac{\beta(\lambda)}{4\pi}\exp\left[-2\int_0^R\sigma_{ext}(\lambda, r)dr\right]$$

$$S(R) = \ln\left[R^2P_r(R)\right] \qquad \frac{dS}{dR} = \frac{1}{\beta}\frac{d\beta}{dR} - 2\sigma_{ext} \qquad \ln\left[\frac{P_1(R)}{P_2(R)}\right] \cong -2\int_0^R\rho[k_1 - k_2]dr$$

$$\overline{\rho}(R) = -\frac{\ln\left[\frac{P_1(R + \Delta R)}{P_2(R + \Delta R)}\right] - \ln\left[\frac{P_1(R)}{P_2(R)}\right]}{2(k_1 - k_2)\Delta R} \qquad A_e = \frac{G\lambda^2}{4\pi} \qquad P_R = P_t\frac{G^2\lambda^2}{(4\pi)^3R^4}\sigma$$

$$\sigma = \frac{\pi^5}{\lambda^4}|K|^2D^6 \qquad K = \frac{m^2 - 1}{m^2 + 2} \qquad \overline{P}_R = P_t\frac{\pi^2G^2|K|^2}{64\lambda^2R^4}\sum_{pulse\ volume}D^6$$

$$Z = \sum_{unit\ volume}D^6 = \int_0^\infty N(D)\,D^6dD \qquad \overline{P}_R = C\frac{|K|^2}{R^2}Z$$

$$a(\sin i + \sin\theta) = m\lambda \qquad h' = ha'/(H - h) \qquad \frac{dl}{d\lambda} = f\frac{d\theta}{d\lambda} \qquad R_a = \frac{H\lambda}{L\cos\theta}$$