AEROSOL OPTICAL DEPTH

Aerosol Optical Depth (AOD) is the measure of aerosols (e.g., urban haze, smoke particles, desert dust, sea salt) distributed within a column of air from the instrument (Earth's surface) to the top of the atmosphere. The voltage (V) measured by a sun photometer is proportional to the spectral irradiance (I) reaching the instrument at the surface. The estimated top of the atmosphere spectral irradiance (I_o) in terms of voltage (V_o) is obtained by sun photometer measurements at Mauna Loa Observatory in Hawaii. The total optical depth (τ_{TOT}) can be obtained using the following equation according to Beer-Lambert-Bouguer law:

$$V(\lambda) = V_o(\lambda)\, d^2 \exp[-\tau(\lambda)_{TOT} * m], \qquad (1a)$$

where V is the digital voltage measured at wavelength λ, V_o is the extraterrestrial voltage, d is the ratio of the average to the actual Earth-Sun distance, τ_{TOT} is the total optical depth, and m is the optical air mass (Holben 1998).

Other atmospheric constituents can scatter light and must be considered when calculating the AOD. The optical depth due to water vapor, Rayleigh scattering, and other wavelength-dependent trace gases must be subtracted from the total optical depth to obtain the aerosol component:

$$\tau(\lambda)_{Aerosol} = \tau(\lambda)_{TOT} - \tau(\lambda)_{water} - \tau(\lambda)_{Rayleigh} - \tau(\lambda)_{O3} - \tau(\lambda)_{NO2} - \tau(\lambda)_{CO2} - \tau(\lambda)_{CH4} \qquad (1b)$$

PRECIPITABLE WATER

The total column water vapor amount determination uses three channels: 675nm, 870nm, and 940nm. The total transmission (T) is computed for 675nm and 870nm using Rayleigh and aerosol optical depths. The total transmission for 940nm (T_{940}) is determined through extrapolation. The extrapolated transmission at 940nm is subtracted from the measured transmission at 940nm (T_{940}) providing the transmission only due to water vapor (T_w). Therefore, the precipitable water (in cm) can be determined using the following equations:

$$\ln [T_w] = \ln[T_{940\ [measured]}] - \ln[T_{940\ [extrapolated]}] \qquad (1a)$$

$$-\ln [T_w] = \ln [V_{o\ 940} * d^{-2}] - \ln[V_{940}] - m * (\tau_{940\ AOT} + \tau_{940\ Rayleigh}) \qquad (1b)$$

$$-\ln [T_w] = a * (m_w * u)^b \qquad (2)$$

$$u = \frac{\left[\dfrac{-\ln T_W}{a}\right]^{1/b}}{m_W} \qquad (3),$$

where u is the precipitable water in cm, T_w is the transmission due to water vapor, a and b are filter-dependent constants, and m_w is the water vapor optical air mass (Schmid 2001, Smirnov 2004).

Angstrom Parameter

The size distribution of aerosols can be estimated from spectral aerosol optical depth, typically from 440nm to 870nm. The negative slope (or first derivative) of AOT with wavelength in logarithmic scale is known as the Angstrom parameter (α). This parameter (see equation 1) can be calculated from two or more wavelengths using a least squares fit. Values of α greater than 2.0 indicate fine mode particles (e.g., smoke particles and sulfates) exist, while values of α near zero indicate the presence of coarse mode particles such as desert dust (Eck 1999).

$$\alpha = -\frac{d \ln \tau_a}{d \ln \lambda} \qquad (1)$$

where α is the Angstrom parameter, τ_a is the aerosol optical depth, and λ is the wavelength.

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