OMAERUV ALGORITHM DESCRIPTION

The OMAERUV algorithm uses as input OMI measured reflectances at 354 and 388 nm to retrieve column atmosphere values of aerosol optical depth (AOD), single scattering albedo (SSA), and Absorbing Aerosol Index (AAI).

1.0 Required Information

1.1 Aerosol models

The algorithm assumes that the atmospheric aerosol column can be represented by one of three aerosol types: desert dust (*DST*), biomass burning carbonaceous particles (*BIO*), and sulfate-based (*SLF*) aerosols. Each aerosol type is characterized by a fixed bi-modal spherical particle size distribution [*Torres et al.*, 2007] with parameters derived from long-term AERONET statistics [*Dubovik et al.*, 2002]. The relative spectral dependence of the imaginary component of refractive in the 354-388 nm range, Δk, is assumed for each aerosol type [*Torres et al.*, 2007; *Jethva and Torres*, 2011]. Each aerosol type is further divided into seven sub-types to account for the variability of the 388 nm imaginary component of the refractive index.Table 1 lists the microphysical properties of the 21 aerosol models.

Type	**Subtype**	**Particle size distribution parameters**					**Refractive Index**	
		$r_g(m_1$	$r_g(m_2$	$\sigma(m_1)$	$\sigma(m_2)$	Fctn m_2	**354 nm**	**388 nm**
	DST-1	0.052	0.670	1.697	1.806	4.35e-3	1.55+0i	1.55+0i
	DST-2	0.052	0.670	1.697	1.806	4.35e-3	1.55+0.0013i	1.55+0.0009i
	DST-3	0.052	0.670	1.697	1.806	4.35e-3	1.55+0.0026i	1.55+0.0018i
DUST	DST-4	0.052	0.670	1.697	1.806	4.35e-3	1.55+0.0056i	1.55+0.0040i
	DST-5	0.052	0.670	1.697	1.806	4.35e-3	1.55+0.0083i	1.55+0.0060i
	DST-6	0.052	0.670	1.697	1.806	4.35e-3	1.55+0.0130i	1.55+0.0920i
	DST-7	0.052	0.670	1.697	1.806	4.35e-3	1.55+0.0230i	1.55+0.0170i
	BIO-1	0.087	0.567	1.537	2.203	2.06e-4	1.50+0i	1.50+0i
	BIO-2	0.087	0.567	1.537	2.203	2.06e-4	1.50+0.006i	1.50+0.005i
	BIO-3	0.087	0.567	1.537	2.203	2.06e-4	1.50+0.012i	1.50+0.010i
SMOKE	BIO-4	0.080	0.705	1.492	2.075	2.05e-4	1.50+0.024i	1.50+0.020i
	BIO-5	0.080	0.705	1.492	2.075	2.05e-4	1.50+0.036i	1.50+0.030i
	BIO-6	0.080	0.705	1.492	2.075	2.05e-4	1.50+0.048i	1.50+0.040i
	BIO-7	0.080	0.705	1.492	2.075	2.05e-4	1.50+0.058i	1.50+0.048i
	SLF-1	0.088	0.509	1.499	2.160	4.04e-4	1.40+0i	1.40+0i
	SLF-2	0.088	0.509	1.499	2.160	4.04e-4	1.40+0.002i	1.40+0.002i
	SLF-3	0.088	0.509	1.499	2.160	4.04e-4	1.40+0.004i	1.40+0.004i
SULFATE	SLF-4	0.088	0.509	1.499	2.160	4.04e-4	1.40+0.006i	1.40+0.006i
	SLF-5	0.088	0.509	1.499	2.160	4.04e-4	1.40+0.008i	1.40+0.008i
	SLF-6	0.088	0.509	1.499	2.160	4.04e-4	1.40+0.010i	1.40+0.010i
	SLF-7	0.088	0.509	1.499	2.160	4.04e-4	1.40+0.012i	1.40+0.012i

Forward radiative transfer calculations of upwelling reflectance at the top of the atmosphere (354 and 388 nm) for the resulting 21 aerosol models were used to generate a set of look-up tables (LUT's) with nodal points in viewing geometry, aerosol optical depth (AOD), aerosol single scattering albedo (SSA), and aerosol layer height (ALH).

1.2 Ancillary Data

Additional global data sets on atmospheric and surface parameters are required by the OMAERUV algorithm. The ways these ancillary data are used in the algorithm are discussed in section 2 of this document. The required data sets are:

-Monthly Climatology of surface albedo at 354 and 388 nm

-Surface Type

-CALIOP-based monthly climatology of layer height of carbonaceous and desert dust aerosols.

-Real time AIRS CO measurements

2.0 Inversion Procedure

2.1 Lambert Equivalent Reflectivity and Absorbing Aerosol Index

The first step in the retrieval procedure is the calculation of the scene 388 nm Lambert Equivalent Reflectivity (LER), and the absorbing Aerosol Index (AAI). A key assumption in the OMAERUV model of the earth-atmosphere system is that the LER of the column atmosphere's lower boundary is wavelength independent in the near UV. Under this assumption, the upwelling near UV radiance at the top of the atmosphere is given by the expression

$$L_\lambda(\theta,\theta_0,\varphi,p_0) = L_\lambda^0(\theta,\theta_0,\varphi,p_0) + \frac{R_\lambda T_\lambda(\theta,\theta_0,p_0)}{1-R_\lambda S_\lambda^b(p_0)} \quad (1)$$

Where L_λ^0 is the path radiance, R_λ is the Lambertian Equivalent Reflectivity of the atmospheric column (including cloud and aerosol effects), T_λ represents the total amount of direct plus diffuse radiation reaching the surface, multiplied by the atmospheric transmission of the diffuse component in the direction of the sensor. The numerator in the second term of equation 1 accounts for the once-reflected radiation whereas multiple reflections by the surface is accounted for in the denominator, in which S_λ^b is the spherical albedo that accounts for the fraction of the reflected radiation scattered back to the surface by the atmosphere.

The LER parameter is calculated by solving for *R* in equation 1 yielding

$$R_{\lambda_0} = \frac{L_{\lambda_0}^{obs} - L_{\lambda_0}^0}{T_{\lambda_0} + S_{\lambda_0}^b (L_{\lambda_0}^* - L_{\lambda_0}^0)} \quad (2).$$

In the above expression λ_0 is 388 nm, and $L_{\lambda_0}^{obs}$ is the OMI observed radiance. The resulting reflectivity is then used back in equation (1) to find the calculated value L_λ^{cal} at λ = 354 nm, associated with the previously calculated reflectivity

$$L_\lambda^{cal} = L_\lambda^0 + \frac{R_{\lambda_0} T_\lambda(\theta,\theta_0,p_0)}{1-R_{\lambda_0} S_\lambda^b(p_0)} \quad (3)$$

The aerosol Index is then calculated as the natural log of the ratio of the actually

$$AI = -100\log\left[\frac{L_{354}^{*}}{L_{354}^{cal}}\right] \quad (4).$$

2.2 Aerosol Type Determination

Aerosol type selection is carried out making use of the AAI and the total column carbon monoxide (CO) given in molecules-cm^{-2}, derived from AIRS observations, as well as surface type considerations. Fore convenience, a dimensionless Carbon Monoxide Index (COI) is defined as the column CO amount divided by 10^{18} molecules-cm^{-2}. Table 1 lists the criteria used in aerosol type selection based on threshold values of AI and COI. Note that COI threshold values are not the same for both hemispheres.

	AAI	**COI**	**Surface Type**	**Aerosol Type**	**Retrieval Approach**
Ocean	≥ 0.5	>2.2 NH (1.8 SH)	n/a	Smoke	Two-channel
Ocean	≥ 0.5	≤2.2 NH (1.8 SH)	n/a	Dust	Two-channel
Ocean	<0.5	-	-	-	No retrieval
Land	≥ 0.5	>2.2 NH (1.8 SH)	All	Smoke	Two-channel
Land	≥ 0.5	≤ 2.2 NH (1.8 SH)	All	Dust	Two-channel
Land	< 0.5	>2.2 NH (1.8 SH)	All	Sulfate	Two-channel
Land	< 0.5	≤ 2.2 NH (1.8 SH)	All but arid, semi-arid	Sulfate	Single channel
Land	< 0.5	≤ 2.2 NH (1.8 SH)	arid, semi-arid	Dust	Single Channel

2.3 Retrieval Approach

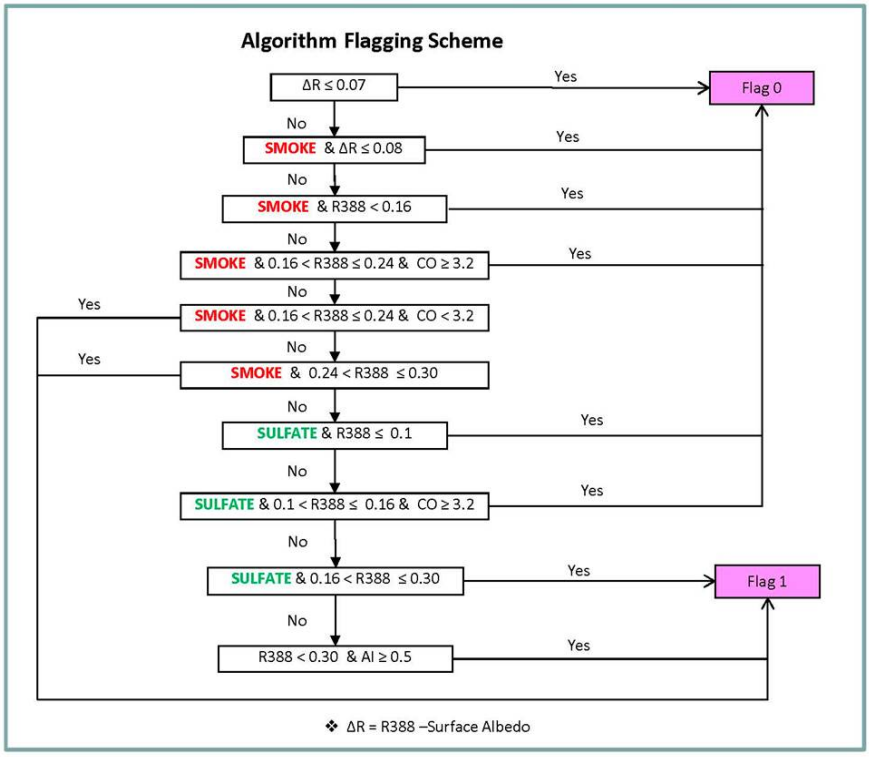
Slightly different retrieval approaches are applied over the oceans and the continents. Over the oceans, the retrieval is only carried out when either DST or BIO aerosols are present as indicated by the AAI parameter (see Table 1). No retrieval takes place over the oceans for AAI values less than 0.5. Retrievals over land, on the other hand, are carried out under all conditions regardless of the value of AAI. Depending on the magnitude of the AAI and COI parameters as well as the aerosol type, two retrieval approaches are used. They are referred to as two-channel and single-channel retrievals (last column Table 1).

In the two-channel approach, observations at 354 and 388 nm are used to simultaneously derive AOD and SSA for five different assumptions on aerosol layer height (surface, 1.5, 3, 6, and 10 km). A best-guess aerosol layer height is then selected. If either the smoke or aerosol type has been selected, the best guess ALH is given by a CALIOP-based climatological value [*Torres et al.*, 2013]. If the CALIOP climatology does not provide an ALH entry, an ALH assumption is made that depends on aerosol type and location. Carbonaceous aerosols layers within 30˚ of the Equator are assumed to have maximum concentration at 3 km above the surface whereas mid and high-latitude (pole wards of ±45˚) smoke layers are assumed to peak at 6 km. The height of smoke layers between 30˚ and 45˚ latitude in both hemispheres is interpolated with latitude between 3 and 6 km. The location of desert dust aerosol layers varies between 1.5 and 10 km, and is given by a multiyear climatological average of Chemical Model Transport (CTM) calculations using the GOCART model [*Ginoux et al*, 2001] gridded at a resolution of 2.5˚. Thus, in addition to retrievals at five standard ALH values, retrieved values of AOD and SSA at the best-guess value of ALH are also reported.

Over scenes when the aerosol absorption signal is low, the sulfate aerosol type is selected, and the single-channel retrieval is applied for all land surface categories except for those classified as arid or semi-arid. Dust aerosol type is selected for arid and semi-arid surface categories. In those situations, AOD is retrieved from the 388 nm OMI observation assuming a value of 1.0 for SSA. A vertically decaying distribution is used, in which aerosol concentration is largest at the surface and decreases exponentially with height.

2.4 Cloud Screening

The level of sub-pixel cloud contamination in each OMI pixel is determined is determined on the basis of aerosol type, AI, COI, $R_{388,}$ and ΔR considerations as shown in the flow diagram below. The difference ΔR (i.e., R_{388}-A_{388}), represents reflectivity increases beyond the surface reflectance A_{388}.



Sub-pixel cloud contamination is characterized by an algorithm Quality Flag (QF) whose value is 0 for minimum cloud presence, and has a value of 1 when it is suspected that the retrieval product is affected by significant sub-pixel cloud interference.

3.0 Reported Aerosol Parameters

Retrieved values of AOD, AAOD and SSA are reported at 388 nm. Similar values are also reported at 354 and 500 nm by conversion from the 388 nm retrieval. The wavelength conversion from 388 nm to 354 and 500 nm is done using the spectral dependence associated with the assumed aerosol particle size distribution and retrieved absorption information. The wavelength transformation for carbonaceous aerosols has been revisited to account for the presence of organic carbon. Obtained AAI and LER values are also reported.