3.1.4 ATSK5

Algorithm for Aerosol Optical Property Retrieval

A. Algorithm Outline

(1) Algorithm Code: ATSK5

(2) Product Code: AROP, ARAE

(3) PI names: G60 Teruyuki Nakajima

(4) Overview of algorithm（Status: standard level）

This algorithm has the following objectives:

1. To retrieve aerosol optical thickness at 0.5 micron and any user defined wavelength over ocean surface.
2. To retrieve aerosol Angstrom exponent which is an index of aerosol size distribution over ocean surface.

B. Theoretical Description

(1) Methodology and Logic flow

This satellite remote sensing algorithm retrieves aerosol optical thickness at 0.500nm and user defined wavelength, and Angstrom exponent from two channel radiant data, that is, visible and near-IR, satellite data. Satellite-received radiance is synthesized with four look-up tables (LUTs). For retreivals, ancillary data are needed, which include wind velocity at 10 meter height, ozone and water vapor amount to correct radiance for surface reflectance, ozone and water vapor absorption.

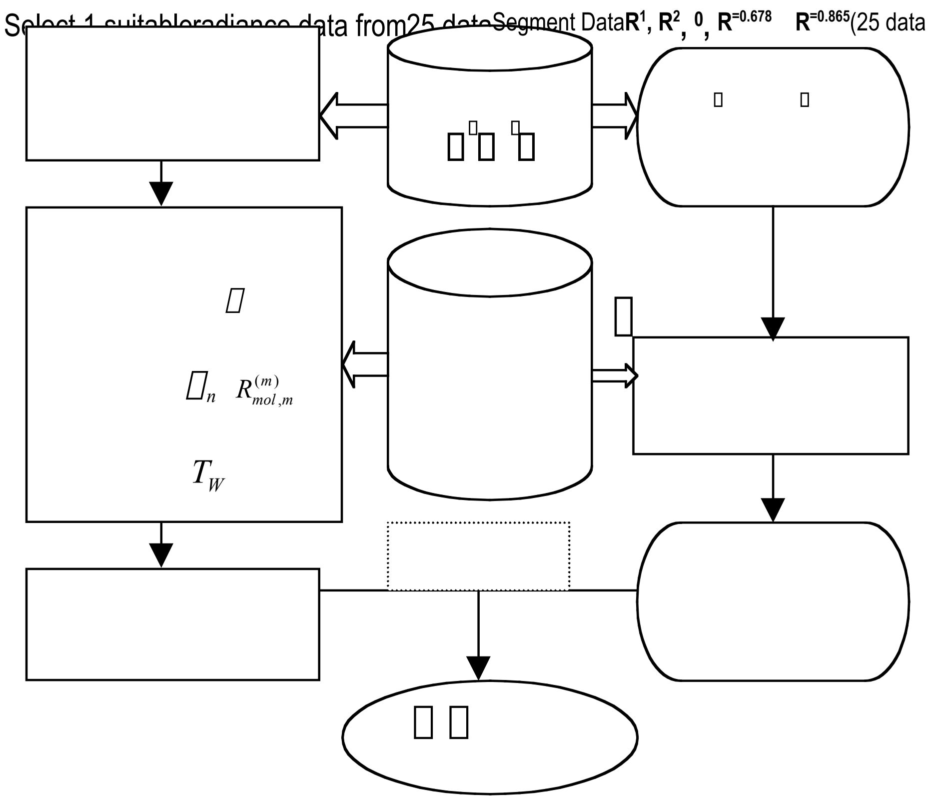


Figure 1. Flow Chart of the Retrieval Algorithm

(2) Physical and Mathematical aspects of the algorithm

By theoretical analysis and numerical simulation, the satellite received apparent reflectance is composed of the following six items:

$$R(\square,\square_0,\square) = T_{O_3} T_W (R_S + R_{mol,m} + R_{aer,m} + R_g) \qquad (1)$$

In which each item can be expressed in the following way:

Single scattering component

$$R_S = \frac{\square\square P(\square)}{\square\square_0 F_0} \frac{1 \square e^{\square\square(1/\square+1/\square_0)}}{1/\square + 1/\square_0} \qquad (2)$$

Multiple scattering component

$$R_{mol,m} = \sum_{m=0}^{2} R_{mol,m}^{(m)} \cos m\square \qquad (3)$$

$$R_{aer,m} = \frac{1}{\square\square_0} \left\{ \sum_{n=1}^{4} \square_n \square_a^n + \square_5 \left[1 \square e^{\square\square_a(1/\square+1/\square_0)} \right] \right\} \qquad (4)$$

Surface reflectance component

$$R_g = r_s(\square,\square_0,\square,\square) e^{\square\square(1/\square+1/\square_0)} \qquad (5)$$

Correction of ozone absorption

$$T_{O_3} = e^{\square\square_{O_3}(1/\square+1/\square_0)} \qquad (6)$$

In this algorithm 4 LUTs are constructed to calculate the Phase fuction *P*, single scattering albedo $\square$, and coefficient of aerosol multiple scattering $\square_n$, and coefficient of Rayleigh multiple scattering $R_{mol,m}^{(m)}$, and Correction factor of water vapor absorption T_W. For accurately calculating radiance in the visible and near infrared channels of GLI, the gaseous absorption by ozone and water vapor has to be taken into account, T_{O_3} is calculated by use of Eq. (6) and T_W is interpolated from LUTs.

A suitable assumption of the aerosol optical model is another important point for realizing a good aerosol retrieval algorithm, here, we introduce a bimodal log-normal volume spectrum for modeling the aerosol size distribution:

$$\frac{dV}{d\ell nr} = \sum_{n=1}^{2} C_n \exp\left[\square \frac{(\ell nr \square \ell nr_{m,n})^2}{2\square_n^2} \right] \qquad (7)$$

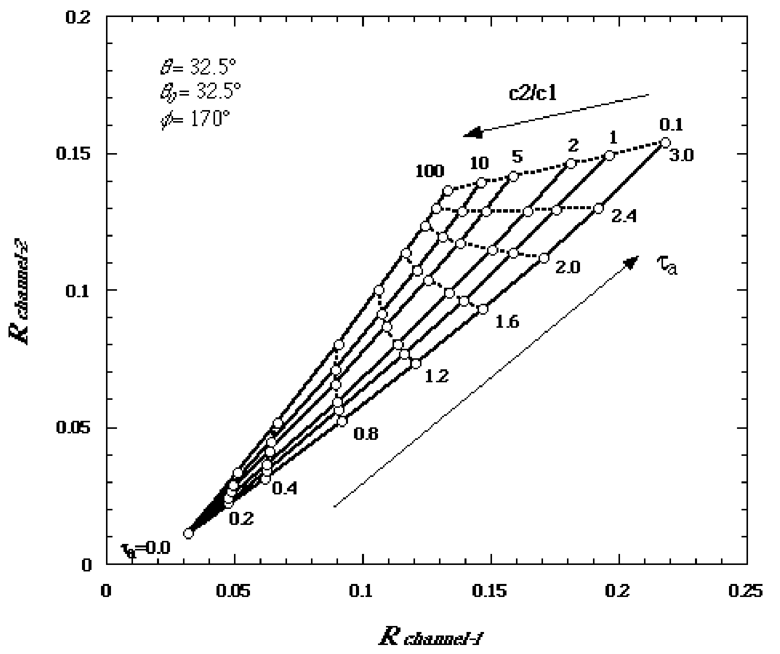
where subscript *n* indicates the mode number, r_{m1} = 0.17 mm, r_{m2} = 3.44 mm, $\square_1$ =1.96, and $\square_2$ =2.37 are adopted for the parameters of the modeled volume spectrum, and the complex refractive index of m=

1.5-0.005i. is used in this retrieving scheme.

As shown in Figure 1, the theoretical reflectance can be reconstructed quickly and accurately by use of the LUTs, and these value are applied to compare with the satellite measured reflectance. The basis of retrieval is the characteristic relationship between apparent reflectance of GLI channe-13 and channel-19 for various values of the aerosol optical thickness at 0.5 □m, □a and the peak ratio □ of the size distribution as shown in Fig. 2, which is caused by the difference in the extinction efficiency in each channel. The figure suggests that the aerosol optical parameters, i.e., □a and □, are retrieved by comparing measured reflectances and theoretical reflectances which are reconstructed from LUTs. It has be found that the peak ratio □, which represents the contribution of large particles, can be used to calculate the Angstrom exponent □, which is defined as,

$$\square = \square \frac{d\ell n \square_{a,\square}}{d\ell n \square} \qquad (8)$$

Retrieving the set of (□a, □) is more essential since the satellite-received radiance is not sensitive to the detailed structure of the size distribution, but depends nearly uniquely on (□a, □).



Channel-1 and -2 for various aerosol loading conditions.

Fig. 2 The relationship between apparent reflectances of NOAA/AVHRR

C. Practical Considerations

(1) Programming, Procedural, Running Considerations

Program Requirements: The following table shows information about the expected software generated from this algorithm.

Program Memory	177KB
Program Size	2564 lines
Required Channels	Channel-13 (678nm) and Channel-19 (865nm)
Necessary/Ancillary Data	Column Water vapor amount and Ozone amount and wind velocity of 10 meter height.
Expected Disk Volume	78548 bytes
Special Programs or Subroutines	22 subroutines

Use of existing data sets for developing algorithms

(2) Calibration and validation
(3) Quality Control and Diagnostic Information
(4) Exception Handling
(5) Constraints, Limitations, Assumptions
(6) Publications and Papers

D. References

Nakajima, T., and A. Higurashi, 1998: A use of two-channel radiances for an aerosol characterization from space. Geophys. Res. Lett., 25(20),3815-3818.

Nakajima, T., and A. Higurashi, 1997: AVHRR remote sensing of aerosol optical properties in the Persian Gulf region, the Summer of 1991. J. Geophys. Res., 102(D14), 16,935-16,946.

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Higurashi, A., 1998: A study of aerosol properties on global scale using satellite remote sensning. University of Tokyo, Ph. D. thesis.

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