Geostationary Satellite Re-Analysis
-Aerosol Retrieval-

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Abstract

Under the project of R-VISSR, Aerosol Optical Thickness from GMS-5/R-VISSR in 2001 is retrieved. As a Angstrom Exponent, Monthly mean values of MODIS Level 3 product are used. In this study, we use both spherical and nonspherical model as aerosols' shape. The probability density function of aerosol optical thickness is quite influenced by the assumption of aerosols' shape. The seasonal variation of aerosol optical thickness derived by this study is consistent with that of MODIS.

Keywords : GMS-5, R-VISSR, aerosol, remote sensing

1. Introduction

Aerosols have a significant impact on earth's radiation budget, but the uncertainty is still large[1)]. GMS-5 (Himawari 5) is a geostationary meteorological satellite, which was launched in 1995, instrumented 4 channels from visible to thermal infrared, and its observational areas are East Asia, the Western Pacific, and Oceania. Generally speaking, geostationary satellites have an advantage of its high time resolution compared with polar satellites, but they also have disadvantages such as fewer available channels, lower space resolution, and limited observational area. East Asia, which is one of observed areas of GMS-5, is an interesting region from a view of aerosols, because it is highly influenced by anthropogenic or dust aerosol. It is considered possible that we can follow the time developing process of aerosols in East Asia by using of the merit of GMS-5. Because the signal of aerosols is not strong, it is necessary that an accurate calibration, when you want to discuss the aerosols' effect quantitatively. The vicalious calibration of the Visible and Infrared Spin-Scan Radiometer (VISSR) onboard GMS-5 is done by Meteorological Satellite Center (MSC) and other institutes, so it is expected that more accurate aerosol remote sensing.

2. Methodology

We assume bi-modal lognormal distribution function as a size distribution function:

$$\frac{dV}{d\ln r} = \sum_{n=1}^{2} c_n \exp\left\{-\frac{1}{2}\left[\frac{\ln(r/r_{m,n})}{\ln S_n}\right]^2\right\}$$

where, r_1=0.17μm, r_2=3.44μm, s_1=1.3, s_2=2.75 [2)3)]

We perform radiative transfer calculation by RSTAR[4)5)] and construct Look Up Tables (LUTs). We retrieve aerosol optical thickness (τ) by using Light-REAP, which is a modified version of REAP[2)]. The Algorithm flow chart of this study is showed in Figure 1.

GMS-5 has just one channel in visible region, so we can only get τ. It is impossible to estimate α, which is an index of aerosol size. α is defined as follows[2)]

$$\alpha = -\frac{d(\ln \tau)}{d(\ln \lambda)}$$

In this study, we use monthly mean value of α produced by MODIS Level 3 product. Figure 2 shows examples of monthly mean α . Generally speaking, α has small value near land area, and large value far from land.

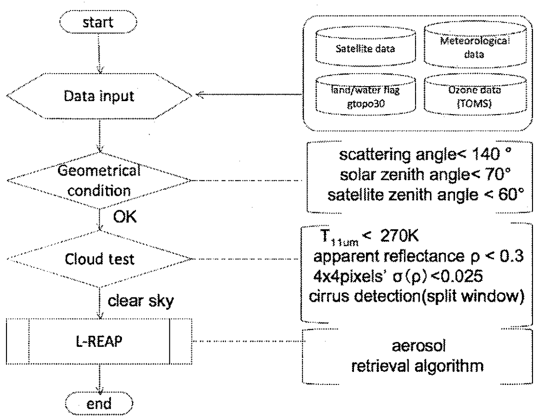

Figure 1: Algorithm flow chart

Figure 3 shows an example of aerosol optical thickness retrieval. In this figure, you can see large τ area around Yellow Sea and East China Sea.

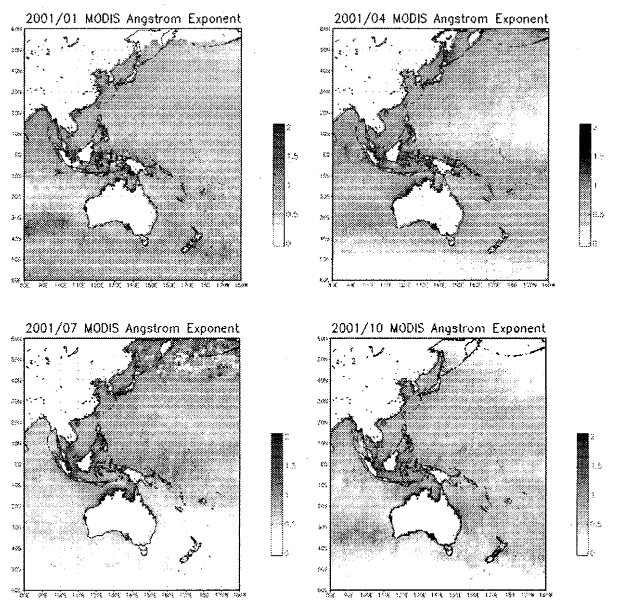

Figure 2: Monthly mean Angstrom exponent by MODIS Level 3 product on January (upper left), April (upper right), July (bottom left), and October (bottom right) in 2001.

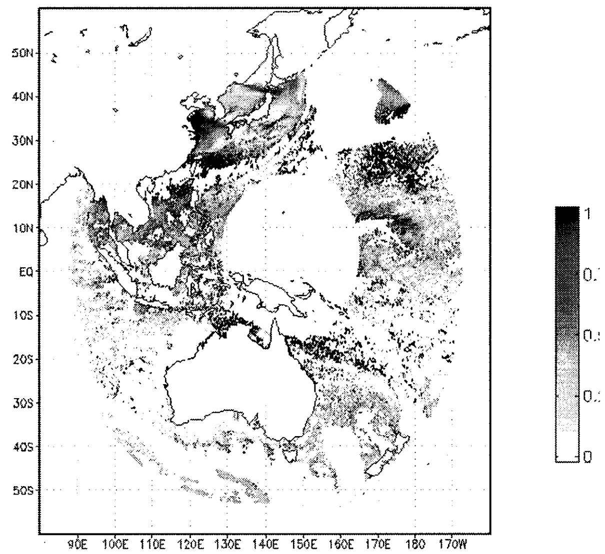

Figure 3: Aerosol optical Thickness at 500nm estimated by GMS-5/R- VISSR on 13 April 2001.

3. Influence of nonsphericity

As aerosols' shape, both spherical model and nonspherical model are used. We used Pollack and Cuzzi's semi-empirical model[6)] as nonspherical aerosol model. The nonsphercial parameter of Pollack and Cuzzi are set as (x0, G, r) =(7.0, 10.0 , 1.1) [3)6)7)]. Figure 5 shows the histogram of aerosol optical thickness. X-axis mean aerosol optical thickness, and Y-axis mean probability density function. Monthly mean τ of each time (from 00UTC to 06UTC) in April 2001 are shown. Upper figure of figure 5 shows the case of spherical model, and down figure shows the case of nonspherical model. In nonspherical case, the shape of graph of each time is relatively close. But, in spherical case, the shape of graph depends on time. We can see the decrease of τ in the noon. The assumption of the shape of aerosol is important when we want to see one day's time development of τ.

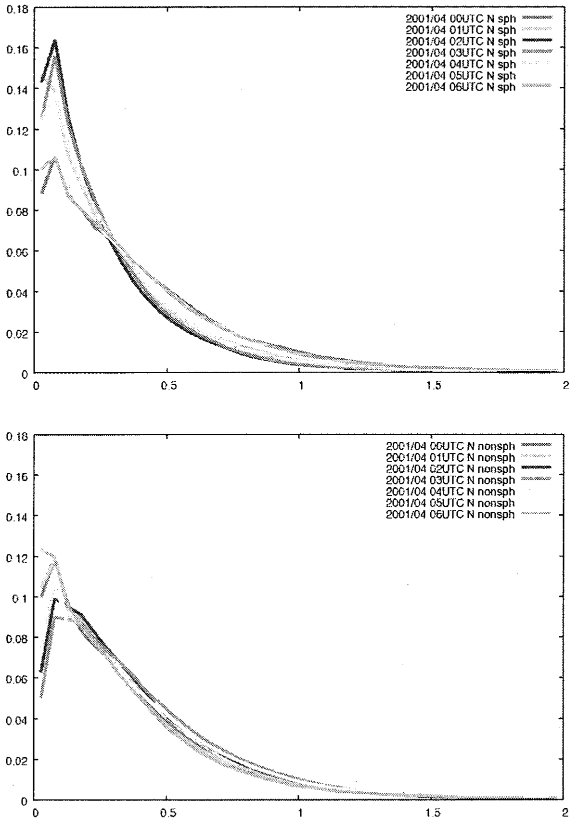

Figure 5: Histograms of τ_a. Spherical model (up) and nonspherical model (bottom) are used. X- axis are τ, and Y-axis are probability density function. We use τ value in northern part of R-VISSR area (N60-EQ, E80-W20)

4. Seasonal variation and comparison with MODIS product

Figure 6 shows monthly average of τ at 500nm by GMS-5/R-VISSR in January, April, July, and October. Figure 7 shows zonal means of τ. Generally speaking, southern hemisphere has smaller value of τ compared with northern hemisphere. Zonal mean of Aerosol Optical Thickness in southern hemisphere is about 0.1~0.2. Especially speaking, t has a very small value in July over the South Pacific Ocean and the Indian Ocean. In April, you can see a large τ in the North Pacific Ocean. This is thought to be the influence of yellow sand events. In April, zonal mean of τ value is about 0.4~0.5 around N40.

Figure 8 shows monthly mean of τ by MODIS Level 3 product. Roughly speaking, the pattern of τ derived by GMS-5/R-VISSR seems to be consistent with MODIS product. Our products have more missing pixels around the equator compared with the product of MODIS. This is because the differences of cloud detection method and the space resolution. MODIS can do detailed cloud detection . Sampling rate is very different between these products. GMS-5 did much more observations than MOIDS in one day. This difference can make some influence for the products.

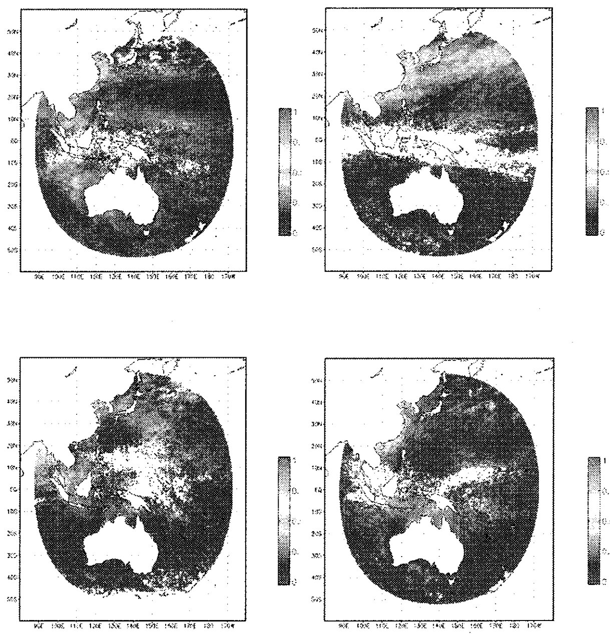

Figure 6: Monthly mean Aerosol Optical Thickness estimated by GMS-5/R-VISSR on January (upper left), April (upper right), July (bottom left), and October (bottom right) in 2001.

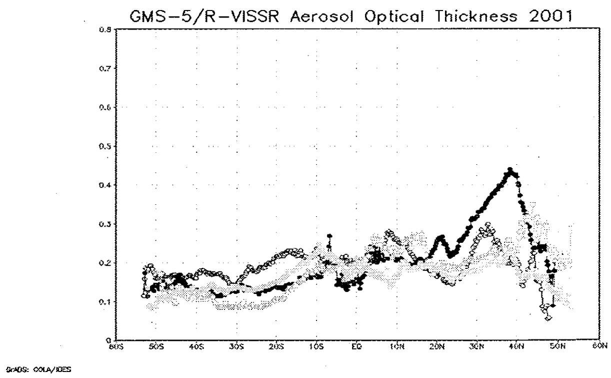

Figure 7: Zonal mean of Aerosol Optical Thickness estimated by GMS-5/R-VISSR. White, black, green, and yellow line mean January, April, July, and October in 2001 respectively.

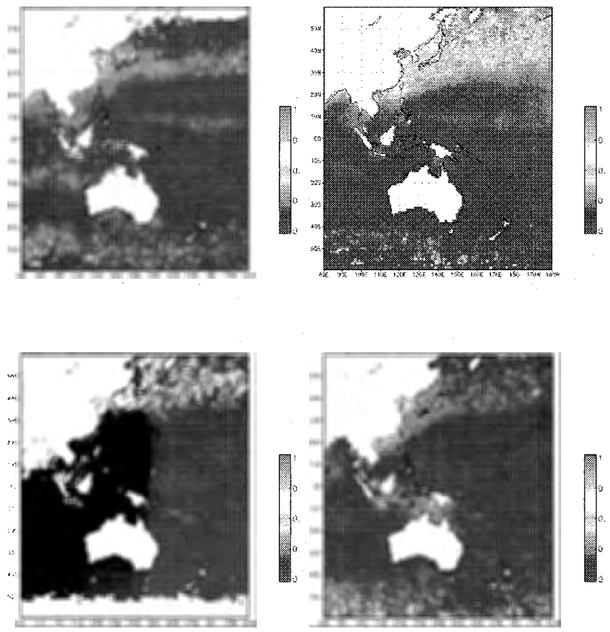

Figure 8: Monthly mean Aerosol Optical Thickness by MODIS Level 3 product on January (upper left), April (upper right), July (bottom left), and October (bottom right) in 2001.

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