THE MODIFIED BRIGHTNESS TEMPERATURE DIFFERENCE FOR AEROSOL DETECTION

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ABSTRACT:

This study investigated the Brightness Temperature Difference threshold as criterion between aerosols and clouds in conjunction with radiative transfer model. Surface temperature is caused by a significant error over 50% in the BTD threshold. In addition, The BTD threshold contains the uncertainties about 20% due to the surface emissivity and 8% due to the satellite zenith angle. Therefore, we have composed the Look-up table for BTD between 11 ㎛ and 12 ㎛ according to satellite zenith angle, surface temperature, and surface emissivity. The modified BTD show the enhanced signal, especially over bright surface such as desert in China. However, a weak aerosol signal over Ocean remains in the modified BTD.

KEY WORDS: Aerosols, Brightness Temperature, BTD, GMS

1. INTRODUCTION

Recently, there has been growing interest in the aerosols in Asia, because of industrial development and desertification in Asian continent. Tropospheric aerosols play important roles not only as an air pollutant but also a controller of the global energy budget through direct and indirect radiative forcing. However, the effects of aerosols include the uncertainty in global climate. It is able to detect the aerosols from ground measurements and field campaign. National Aeronautics and Space Administration (NASA) operate the Aerosol Robotic Network (AERONET), which is a ground-based aerosol monitoring system and offer the aerosol properties such an aerosol refractive index, size distribution. Ground-based observation provides high quality of data, but is provides only limited spatial and temporal coverage. On the other hands, the satellite measurements are able to provide the global scale data. Therefore, the satellite measurements are significant to detect the aerosol signal.

Infrared band has shown a weakness in detecting aerosols due to relatively high error to shortwave bands, it takes an advantage of detecting the aerosol signal over high reflecting surface and at nighttime. Wen and Rose(1994) suggested the Brightness Temperature Difference (BTD) method to retrieve particle sizes, cloud optical depth and ash mass in volcanic clouds from thermal infrared satellite data. However, infrared bands are sensitive to the surface temperature, surface emissivity, water vapor amount, and aerosol properties etc.

We have investigated how infrared bands are sensitive to these factors in conjunction with radiative transfer model, Rstar5b. Based on this analysis, we have modified the BTD threshold as criterion between aerosols and clouds and compared the BTD threshold between Geostationary Meteorological Satellite (GMS) and Moderate Resolution Imaging Spectroradiometer (MODIS). The modified BTD threshold is applied to GMS and MODIS data on April 7, 2000.

2. DATA AND METHODOLOGY

Upwelling thermal infrared radiation between 11 ㎛ and 12 ㎛ from the earth's surface is selectively scattered and absorbed by airborne particles. Ice and liquid water particles preferentially absorb longer wavelengths while dust aerosol particles preferentially absorb shorter wavelengths (Fig. 1). Therefore, BTD shows a negative value in dust aerosols and a positive value in clouds.

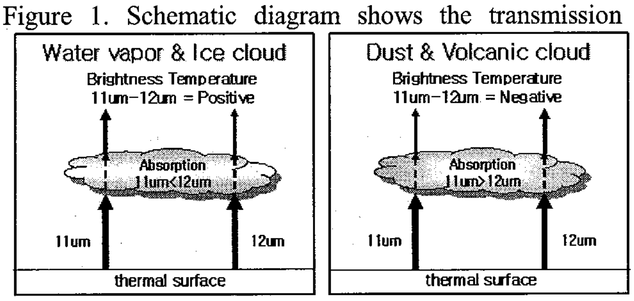


Figure 1. Schematic diagram shows the transmission through meteorological clouds and aerosols at the wavelength of 11 ㎛ and 12 ㎛.

The BTD threshold as criterion between cloud and aerosols is changeable for satellite measurements due to the spectral response function. In addition, the BTD threshold is sensitive to surface emissivity, surface temperature, satellite zenith angle, water vapor etc. However, it is impossible to know the water vapor amount in atmosphere. Therefore, we have investigated the BTD threshold according to surface temperature, surface emissivity, and satellite zenith angle in conjunction of with radiative transfer model, Rstar5b.

Based on this analysis, we have composed the Look-up table of modified threshold according to surface emissivity, surface temperature, and satellite zenith angle. In order to apply the Look-up table approach, we utilized the land surface temperature, sea surface temperature and surface emissivity from MODIS L3 data which is averaged 0.1° x 0.1°. To obtain the surface temperature for clear condition, we used the MODIS data during 8 days. Based on surface data from MODIS, we have applied the modified BTD threshold to GMS and MODIS data.

3. RESULTS AND DISCUSSION

3.1 The analysis of BTD threshold

3.1.1 Surface Emissivity

The surface emissivity is variable according to the status of surface. The lowest value in surface emissivity of MODIS L3 data shows about 0.8 over desert. On the other hands, the highest value is almost 1.0 over vegetation area. Based on this analysis, we have calculated the BTD threshold using radiative transfer model. The BTD threshold of MODIS ranges from -0.3 to 0.3 in Figure 2. However, the BTD threshold in GMS is not sensitive to emissivity more than that in MODIS. In general, the presence of dust aerosols shows a value from -2.0 to -3.0 in BTD. Therefore, the BTD threshold contains the uncertainties about 20% in MODIS and 4% in GMS due to the surface.

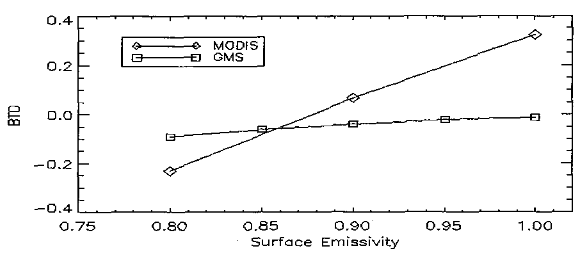


Figure 2. The BTD threshold as a function of surface emissivity at satellite zenith angle of 30° and surface temperature of 280°K.

3.1.2 Surface Temperature

The brightness temperature of infrared bands is related to the surface temperature, which is sensitive to the status of surface and observation time. The surface temperature at daytime is higher than that at nighttime and presents the lower value after raining due to water evaporation. Figure 3 shows the theoretical BTD threshold at MODIS and GMS. As surface temperature increased, the BTD threshold also increased. The BTD thresholds vary by 2.0 in GMS and 4.0 in MODIS with variation of surface temperature as shown in Figure 3. This analysis suggests that surface temperature caused a significant error in BTD.

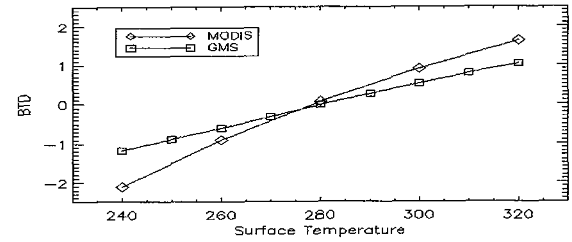
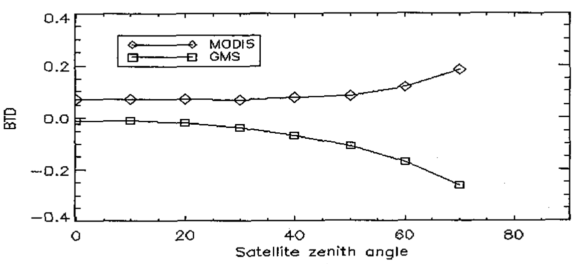


Figure 3. The BTD threshold as a function of surface temperature at satellite zenith angle of 30° and surface emissivity of 0.9.

3.1.3 Satellite Zenith Angle

Aerosols are present as a laver in atmosphere and show different path length due to the position of satellite measurements. Therefore, the BTD threshold has an error caused by satellite position determined by satellite zenith angle in infrared bands. As the satellite zenith angle increase, the BTD threshold decrease in GMS and increase in MODIS. In addition, the variation of BTD threshold at GMS is higher than that at MODIS. However, an error caused by satellite zenith angle is smaller that caused by any other factors.



3.2 Application

Figure 5 shows the MODIS RGB image on April 7, 2000. The aerosols are located as a belt over Ocean and Korea peninsular. MODIS passed through East-Asia at 3:20UTC. Therefore, we utilized the GMS data at 03UTC and 04UTC on April 7, 2000. To apply the Look-up table to GMS and MODIS data, we have composed the database of surface temperature over land and ocean using the MODS L3 data.

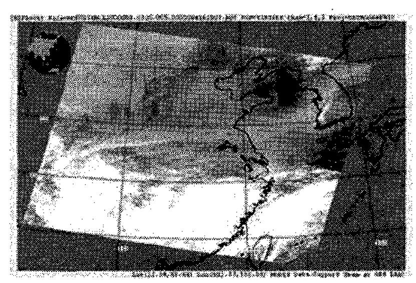


Figure 5. The MODIS RGB image on April 7, 2000.

3.2.1 GMS

The BTD shows a negative value under aerosol condition as expected in Figure 6. However, the BTD present a weak signal over ocean and bright surface such as deserts in China. Figure 7 shows the BTD using the modified BTD threshold at 3:00UTC and 4:00UTC on April 7, 2000. The modified BTD show an enhanced aerosol signal and represent the presence of aerosol over bright surface. However, the modified BTD show a weak aerosol over ocean.

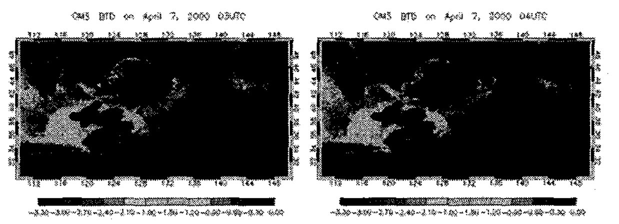


Figure 7. The BTD using general BTD threshold at 3:00UTC(left) and 4:00UTC(right) on April 7, 2000.

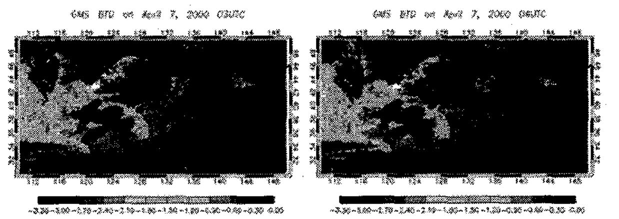


Figure 8. The BTD using modified BTD threshold at 3:00UTC(left) and 4:00UTC(right) on April 7, 2000.

3.2.2 MODIS

The variation of modified BTD threshold in MODIS is higher than that of that in GMS due to the spectral response function of wavelengths. The modified BTD in MODIS shows is similar with that in GMS. The BTD signal enhanced the presence of aerosols over bright surface. However, the BTD remained uncertainties over ocean.

4. CONCLUSION

Infrared bands take an advantage of detecting aerosols signal over brightness surface and at nighttime. However, Infrared bands are associated with surface temperature, surface emissivity, water vapor, aerosol properties etc. In this study, we have investigated the BTD threshold according to surface emissivity, surface temperature, and satellite zenith angle. The BTD threshold shows the different variation between MODIS and GMS. The BTD threshold in MODIS increase and that in GMS decrease as satellite zenith angle increase. The variation of BTD threshold in MODIS is higher than that in GMS. Specially, surface temperature is caused by significant error over 100% in BTD.

Based on this analysis of the BTD threshold, we have modified the BTD threshold and applied it to GMS data on April 7, 2000. The modified BTD show the enhanced signal, especially bright surface. However, a weak aerosol signal over Ocean remains in the modified BTD. In further study, we are going to analyze a weak aerosol over signal Ocean.

REFERENCE

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