CGMS

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CMA Report on Operational Dust Storm Remote Sensing

Summary of the Working Paper.

This working paper reports CMA work of monitoring the outbreak and extension of dust storm from satellite. It mentioned that dust monitoring is one of operational tasks of NSMC. It describes the method to identify the outbreak of dust storm and the quantitative algorithm to retrieve the optical depth and particle size. The report mentioned that the identification and quantitative retrieval algorithm has been integrated into the operational system for dust storm monitoring.

CMA Report on Operational Dust Storm Remote Sensing

1. Introduction

Dust storms often occur in the spring season and influence large areas of northern China. During a dust storm event, the concentration of dust particles in the atmosphere increases significantly. The increased dust concentration produces air quality hazards along the transportation routes. Dust storms may also have climatic influences on regional and global scales through their interactions with the solar and terrestrial radiative fields.

Satellite monitoring is a powerful tool for studying the properties of large-scale dust storms. Since the 1970s, scientists have succeeded in identifying the outbreaks of dust storms from satellite images by use of two different techniques, the VIR (visible and nearinfrared) technique and the TIR (thermal infrared) window technique. It has been shown that the TIR technique has the distinct advantage in detecting dust storms over high albedo surfaces and in nighttimes.

This paper gives a general introduction on satellite remote sensing dust storm in National Satellite Meteorological Center (NSMC).

2. The Identification Algorithm

The thresholds of dust in satellite image were investigated by the probability dense function (PDF) and cumulative distribution function (CDF). The sampled targets include clouds, clear sky over land, clear sky over ocean, dust. 11 thresholds were used in visible and infrared band. The 11 thresholds are listed in Table 1.

Table 1. Thresholds Used in Dust Identification

Threshold	Purpose
0.64 um Reflectance	Surface Reflectance Check (cloud, clear, dust)
Reflectance Ratio between 0.47 um and 0.64 um	Dust Information Enhanced in Reflectance
11 um Brightness Temperature	Surface Temperature Check (cloud, clear, dust)
3.7 um Brightness Temperature	Dust Information Enhance in BT
Brightness Temperature Difference between 11 um and 12 um	Dust Information Enhance in BTD
Brightness Temperature Difference between 11 um and 3.7 um	Dust Information Enhance in BTD
Infrared Difference Dust Index (IDDI)	Dust Information Enhance from clear sky
Normalized Difference Snow Index	Dust check over snow
Normalized Difference Vegetation Index (NDVI)	Dust check over vegetation
Maximum Normalized Difference Vegetation Index (MNDVI)	Dust check over vegetation
Standard Deviation of 0.47 um Reflection	Dust check over ocean

3. The Quantitative Retrieval Algorithm

The quantitative retrieval algorithm has been developed in NSMC. The optical thickness, particle radius, and density of dust can be retrieved from this algorithm. Aerosol physical parameters (complex refraction index and particle size distribution) were pre-selected for the dust retrieval in the algorithm. Radiances of 8.7 um, 11um and 12 um in IR window spectral bands are calculated with a radiative transfer model that includes Mie scattering and the Discrete Ordinates Radiative Transfer (DISORT). Aerosol microphysical parameters (complex refraction index and particle size distribution), surface temperature, and dust layer top temperature are a priori inputs . The background land surface temperature is derived from previous day clear sky 11 μm BT observation in the same area and the same UTC time. Only two layers (surface and dust) are assumed in the forward model. Therefore, temperature profile is not necessary, only surface temperature and effective dust layer temperature is required. Infrared window brightness temperatures (BT) at 11 µm show a quasi-linear relationship with dust optical thicknesses and the split window BT difference (BTD) between 11 and 12 µm shows a quasi-linear relationship with the particle radius. The 8.7 µm band is very useful to infer the dust prop erty over desert. However, it is not used in retrieval yet because the variation and uncertainty of surface emissivity is large over desert. Look-up tables (LUT) have been generated with the radiative transfer model to create a relationship between the dust microphysical properties and BT as well as BTD. Retrieval uses two spectral bands to derive two parameters (optical thickness and particle radius) The dust density is derived from the two parameters.

The algorithm has been applied to process MODIS/EOS, VISSR/FY-2, VIRR/FY-3, SEVIRI/MSG data. Figure 1 gives the sampled dust data from MODIS observation and the look-up table calculation from forward model. Figure 2 shows the dust retrieval results in optical thickness, particle effective radius and column dust density.

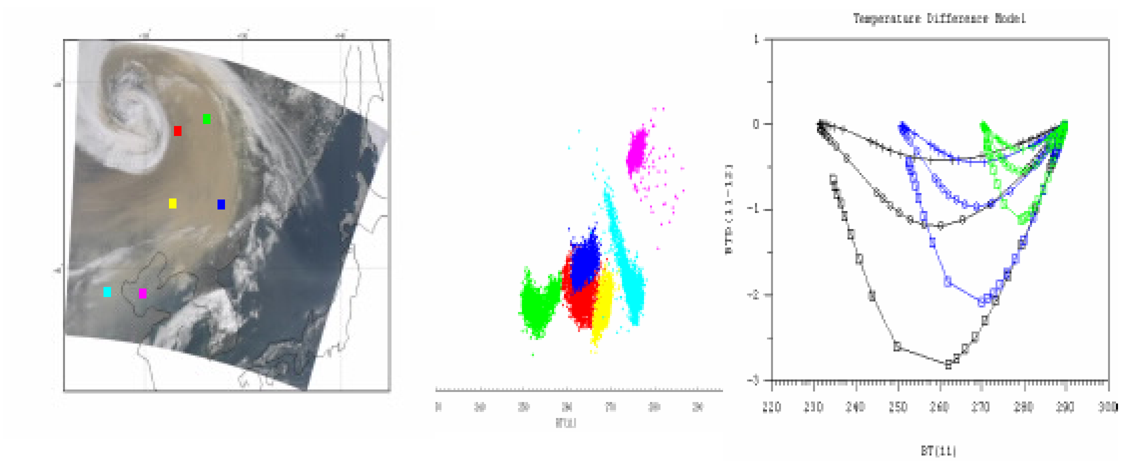

Figure 1 Sampling dust data and Look-up table calculation

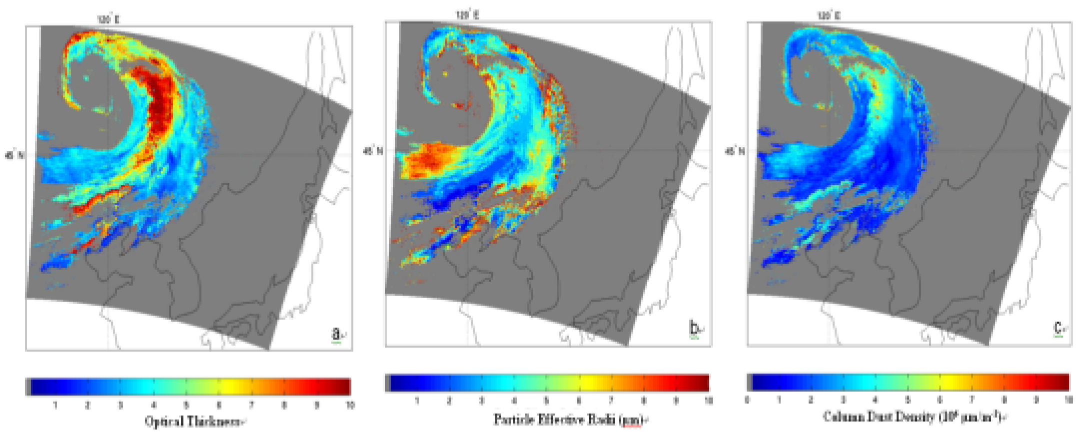

Figure 2 Dust retrieval results in optical thickness, particle effective radius and column dust density

4. The Operational System on Dust Storm Monitoring

The identification and quantitative retrieval algorithm has been integrated into the operational system on dust storm monitoring in NSMC. The operational dust monitoring system includes 4 parts: 1) data preparation segment, 2) data processing segment, 3) task control and management segment, 4) thematic product generation and service segment. Part 1 and 2 run in the background automatically according the task schedule.