MODIS Dust Mask Product for National Weather Service (NWS) Dust Forecast Verification

Shobha Kondragunta[1], Jian Zeng[2], Pubu Ciren[3] , and Chuanyu Xu[4]

1. Center for Satellite Applications and Research, NOAA/NESDIS, College Park, Maryland

2. Earth Resource Technology Inc., Laurel, MD

3. Riverside Technology Inc., College Park, MD

4. I.M. System Group, Rockville, MD

1. Introduction

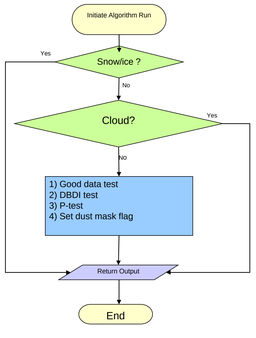
Episodic events such as dust outbreaks impact human health and economy. Therefore, it is desirable to have information on the time, location and the spatial extent of these outbreaks for the monitoring and forecasting of air quality. MODIS Dust Mask detection algorithm takes advantage of the spectral features of dust in the visible and thermal Infrared. The fundamental principle of the detection algorithm depends on spectral and spatial threshold tests which separate dust from clouds and clear-sky over water and land. MODIS Dust Mask algorithm has been tested for different dust storms and compared to other satellite products such as CALIPSO to determine detection limit and accuracy. Based on the CALIPSO comparisons, MODIS dust mask algorithm can detect dust at concentrations 14 μg/m^3 or higher with an accuracy of ~70%. Dust episodes of 2011 in the United States were studied and compared to NWS Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) dust forecasts. Analysis shows that Figure of Merit in Space (FMS) between dust forecasts and dust detection is ~21% for 0.5μg/m^3 and ~1.4% for 10μg/m^3 concentration levels.

2. Detection algorithm

❑Uses spectral contrast and variability tests for different channels ranging from deep-blue to NIR (near InfraRed) to determine the presence of dust in MODIS granules.

❑Use the dust mask pixels to tag the independently derived MODIS aerosol optical depth (AOD) product in those pixels as “dust AOD”.

❑Converts dust AOD to dust concentration using mass extinction efficiency and the assumption that the dust aerosols are present in the lowest 5 km.

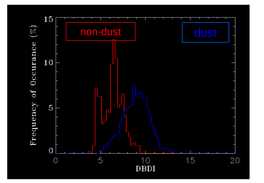


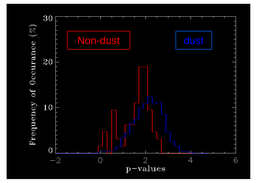
$$DBDI = -100*[\log_{10}(R_{411nm}/R_{442nm}) - \log_{10}(R'_{411nm}/R'_{442nm})]$$

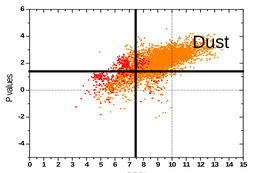
$$P = -10*[\log_{10}(R_{411nm}/R_{2.11\mu m})]$$

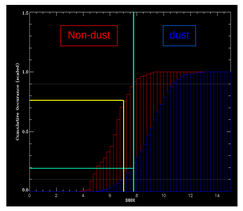
Where R is the reflectance at Top of the Atmosphere (TOA), and R’ is the Rayleigh scattering.

Main Flow Chart of NESDIS MODIS DUST Detection Algorithm









DBDI>7.5 & P-value>1.3

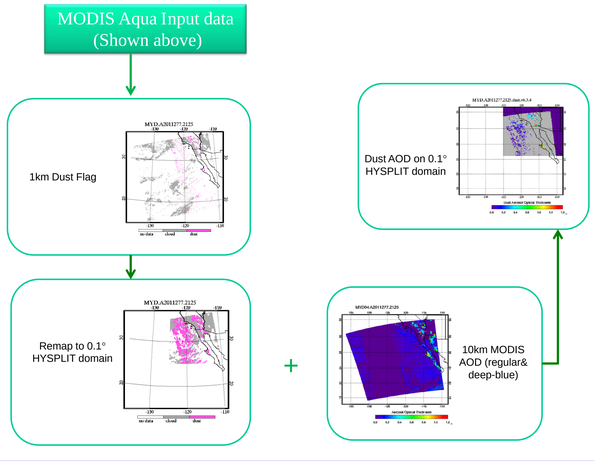
DBDI and T-value sensitive tests

3. NESIDS MODIS Dust channel input and output

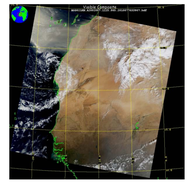
❑Input data

Name	Type	Description	Resolution
Calibrated radiance	input	MODIS level 1 radiance data	1km
Aerosol optical thickness	input	MODIS level 2 Aerosol optical thickness data	10km
Cloud mask	input	MODIS level 2 cloud mask data	1 km
Geolocation	input	MODIS level 1 geolocation data	1km
Snow/Ice mask	input	MODIS level 2 snow/Ice mask data	1 km
Sunglint mask	input	MODIS level 2 sunglint mask data	1 km
Day/night flag	input	MODIS level 2 day/night flag data	1 km

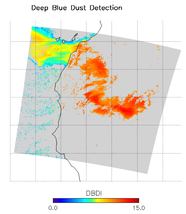
❑ Data Flow Chart

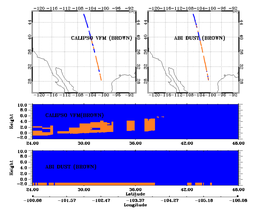


4. Dust Detection Result and Validation



Aqua, January 7, 2002 11:25 UTC





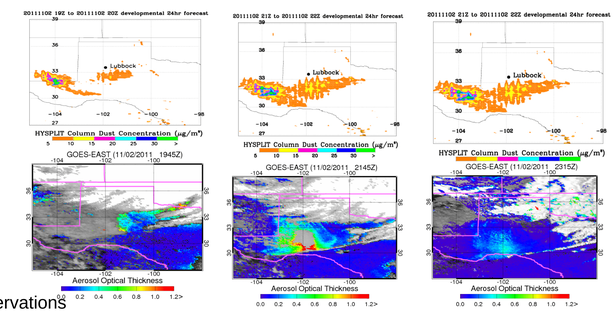
Detection	CALIPSO	MODIS	Samples
True positive	yes	yes	103
False negative	yes	no	9
True negative	no	no	74
False positive	no	yes	46

Accuracy=76.3%
Hit rate=92.0%

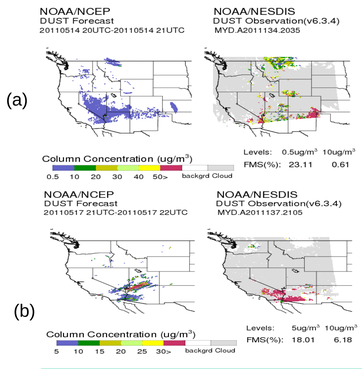
5. HYSPLIT Dust 24-hr Forecasts and Verification

❑HYSPLIT Dust Forecast

A very impressive, widespread dust event occurred this evening beginning around 18Z or 19Z (Nov 2), if not earlier, in west central Texas. This event was the result of ~25kt synoptic scale winds ahead of a cold front. Through 0Z (Nov 3) the dust blew south covering all of west Texas and parts of southeast New Mexico. Additionally, sand was observed to be blowing south from White Sands, NM well into Mexico during those same hours.
----NOAA/NESDIS/OSPO/SSD



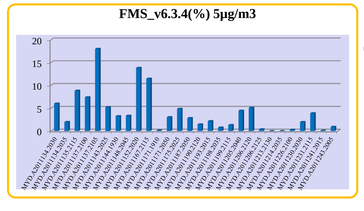
❑Comparisons to NESDIS Dust Observations



❑Figure of Merit in Space (FMS)

$$FMS(\%) = \frac{(P_{hys} \cap P_{obs})}{(P_{hys} \cup P_{obs})} \times 100$$

In equation above, P_{hys} is the dust plume area observed by MODIS and P_{obs} is the dust plume area derived from MODIS. The overlapped area between HYSPLIT and MODIS dust plumes is apportioned to total area in HYSPLIT and MODIS plume areas to calculate FMS.



(C)

May 14th – August 31st, 2011

Dust Column Concentration Comparisons for May 14th(a), May 17th (b) of 2011, and for the period of May 14th to August 31st, 2011(c).

6. Summary and future improvement

1. **NESDIS Dust algorithm is able to provide dust mask with an accuracy of ~70%.**
2. **Detection thresholds needs to be finalized based on the real ABI observations.**
3. **Utilization of Angstrom Exponent will be explored in the future work.**

7. Acknowledgement

Authors would like to thank Ivanka Stajner, Roland Draxler, Geoff Manikin, and Jianping Huang for their support and advice. CALIPSO aerosol data were obtained from NASA DAAC. Although this manuscript has been reviewed internally, this work reflects the views of authors and should not be considered as those of NOAA.