Satellite Detection of Mineral Dust Using MODIS Thermal Infrared Window Channel Data: Application to the NPOESS Program

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1. Introduction

- The effects of mineral dust on earth's climate system remain highly uncertain (**IPCC 2001**) due in part to a lack of data and an understanding of its key properties.
- We present a satellite-based technique for remotely sensing daytime and nighttime dust over two regions frequently burdened by heavy dust aerosol: the Persian Gulf and Niamey, Niger West Africa. The former case is from the United Arab Emirates Unified Aerosol Experiment (UAE^2 -2004), and the latter case was during the deployment of the ARM mobile facility (AMF) in Niamey, Niger.
- Following previous approaches, an integrated technique for detecting dust aerosol using MODIS IR channel data at 3.75, 8.6, 11 and 12μm is given (Hansell et al. 2007). The detection results are compared to the NASA Goddard 'Deep Blue' solar retrieval algorithm (Hsu et al. 2004) and coincident ground-based ARM micro-pulse lidar (MPL) measurements (ARM Program - R. Coulter).
- This technique offers promising potential to a wide variety of applications in the NPOESS Program. It can be used for improving aerosol/cloud remote sensing, SST retrievals, and assessing nighttime dust hazards.

2. Motivation for study

Why is dust/cloud separation necessary ?

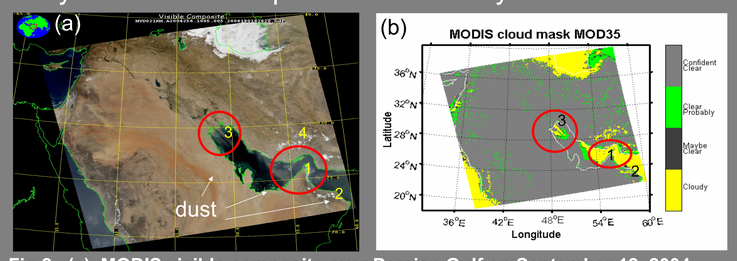


Fig 2. (a) MODIS visible composite over Persian Gulf on September 12, 2004. Dust is evident around the Strait of Hormuz (1), Arabian Gulf (2), and the northern tip of the Persian Gulf (3). Note the clouds to the north of the Strait of Hormuz in southern Iran (4). (b) Compare Fig. 2(a) with the MODIS cloud mask (MOD35) over same area. The regions marked (1-3) are mostly labeled as 'cloud'

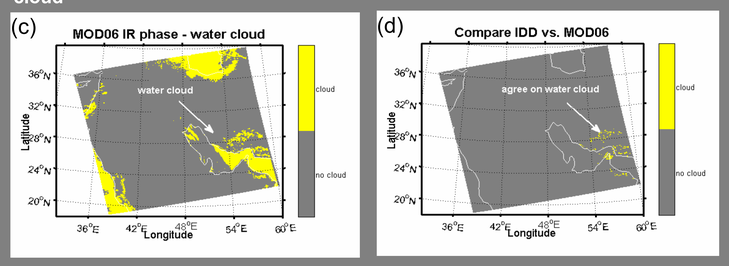


Fig 2. (c) MODIS IR cloud phase (MOD06) over same region showing areas labeled as 'water cloud' (yellow). (d) Comparison of MOD06 cloud classification results with new integrated technique (IDD - see sections 3 & 4 of poster). Yellow points are where MOD6 and IDD both agree on 'water cloud' locations. The remaining points in (c) are due to dust.

3. MODIS Dust Detection - Methodology

We combine/modify 3 prior techniques for detecting dust aerosol for daytime and nighttime applications: (integrated dust detection - IDD)

1) Develop *D*-parameter* based on *D-parameter* approach (Roskovensky and Liou, 2005) – (uses only the thermal IR channels)
   a. D* > 1 → dust; D* < 1 → cloud (Fig. 2a)
2) Add dust to brightness temperature difference (*BTD*) slope method (Strabala et al. 1994) – (dust typically exhibits a negative slope) (Fig. 2b)
3) 3.75-11μm *BTD* method for dust AOT classification

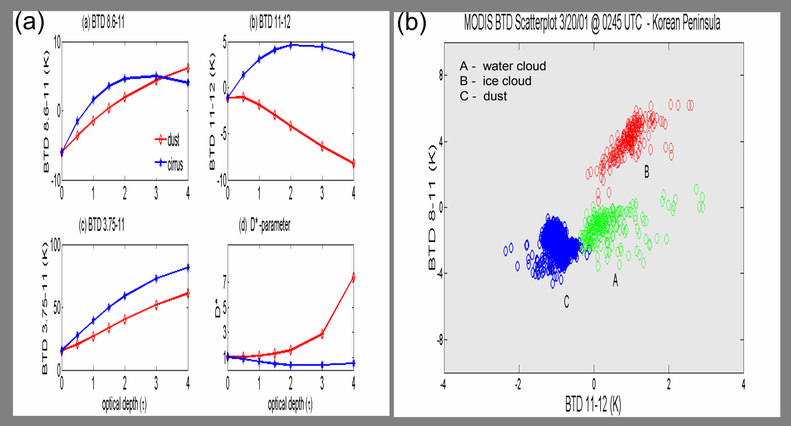
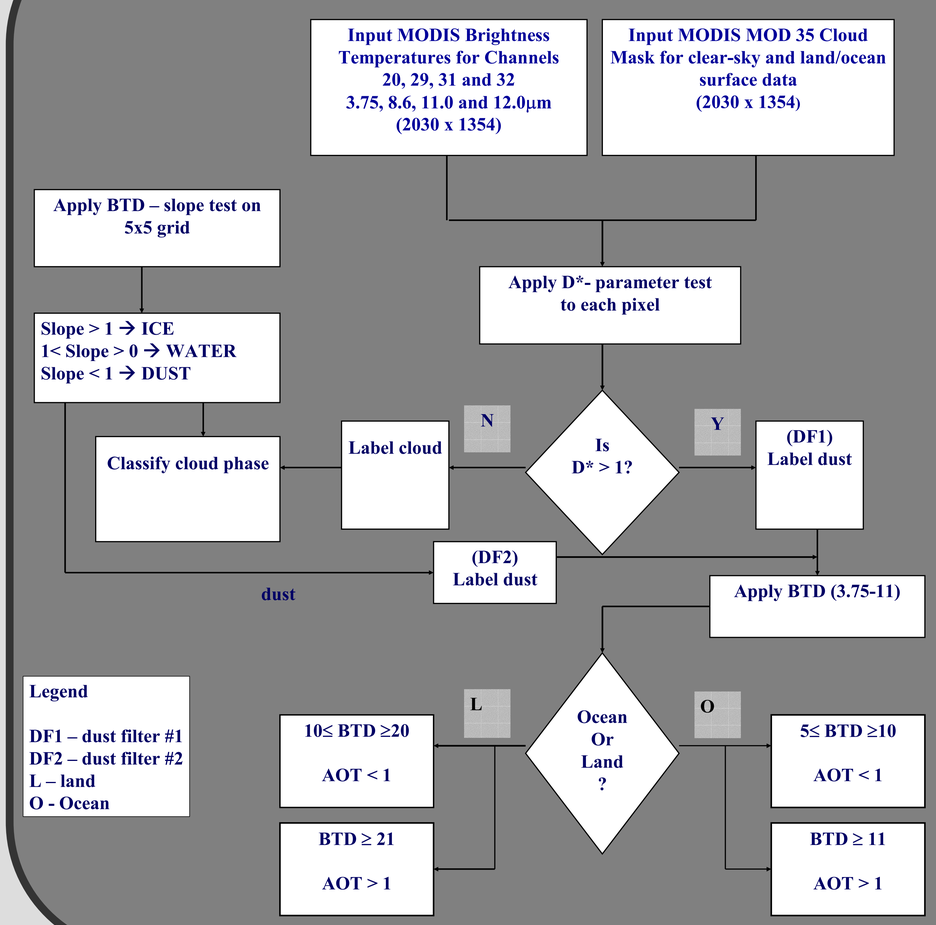


Fig 3. (a) Simulations of *BTD* and *D*-parameter* assuming quartz dust over land (b) Observed MODIS *BTD* of cirrus, low-cloud and dust over Korea on March 20, 2001. Compared to clouds, dust typically displays a negative slope

4. MODIS Dust Detection – Logic Flow Chart & Results



Persian Gulf (UAE^2) - 9/12/04 and mobile ARM site at Niamey, Niger 3/8/06 are shown. The GSFC NASA 'Deep Blue' solar retrieval algorithm (Hsu et al. 2004) and AMF surface MPL are used for day & night validation respectively. IDD detected dust (Fig.3b) agrees well with Deep Blue AOT's > 1(Fig. 3c). IDD captures dust & cirrus clouds over Niamey (Fig. 3e) while ARM MPL also observes the cirrus and dust (Fig. 3f).

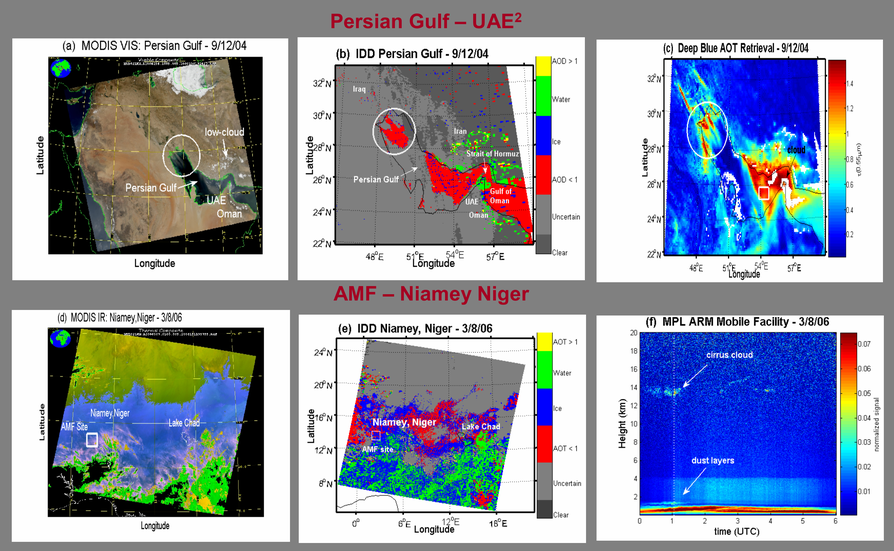


Fig 4. (a). MODIS visible over Persian Gulf (b) Daytime Persian Gulf IDD results. (c) Deep Blue AOT over Persian Gulf (d) MODIS IR over Niamey (e) Nighttime Niamey IDD results
(f) MPL lidar at Niamey

5. Summary/References

- An integrated technique for the remote sensing of dust aerosol using MODIS thermal IR window data during recent field studies was presented
- Dust/cloud misclassification can cause large biases in retrieved atmospheric and surface parameters
- Technique employs 2 thermal dust filters to discriminate dust from cloud and simultaneously classify cloud phase
- IDD results compare favorably with NASA's Deep Blue AOT retrieval (τ > 1) for the Persian Gulf and with the ARM site's MPL detected cirrus/dust over Niamey, Niger
- This technique can be applied to the VIIRS IR channel data with many potential applications

Hansell R.A., S.C. Ou, K.N. Liou, J.K. Roskovensky, S.C. Tsay, C. Hsu, and Q. Ji (2007) , Simultaneous Detection/Separation of Mineral Dust and Cirrus Clouds Using MODIS Thermal Infrared Window Data, *Geophys. Res. Lett,34, L11808,doi:10.1029/2007GLO29388*

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Coulter, Rich – mentor to ARM MPL data. MPL Datset acquired through the ARM data archive