

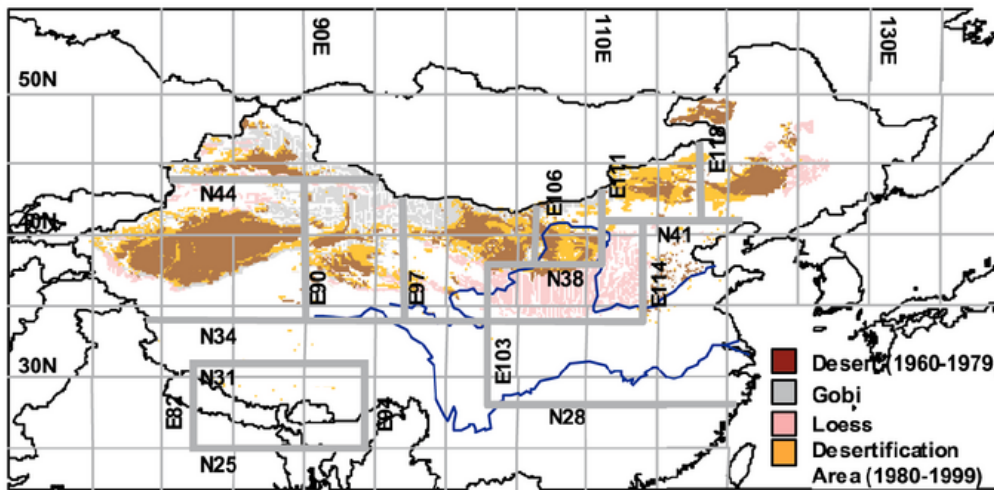
# Examining effect of Asian dusts on the AIRS-measured radiances from radiative transfer simulations

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# Asian Dust



Chinese desert distributions from 1960 to 1979 and desert plus desertification areas from 1980 to 1999. Adapted from Zhang et al. (2003).



# Backgrounds

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## Visible (VIS):

- Effects of dust on blue and yellow bands are much different.
- Limitations over bright surface and daytime-only retrieval

## Infrared (IR):

- Dust detection over high-albedo surfaces and during nighttime is possible.
- Sensitive to water vapor and other gases

It is valuable to employ **improved IR measurements** with a sufficient spectral resolution to distinguish the IR radiative signature of mineral dust from others (e.g. Sokolik, 2002).

 **Hyperspectral sensors** (AIRS, IASI)

# Radiative transfer simulation procedures

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**Surface properties**

$T_s, \epsilon_s$

**Atmospheric information**

$T_{\text{air}}(z), \text{WV}(z), \text{O}_3(z)$

**Asian dust properties**

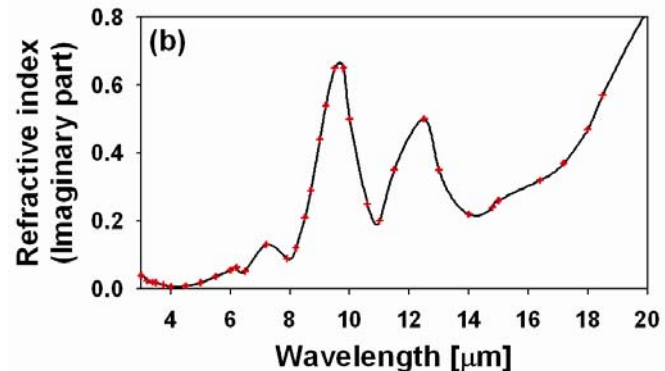
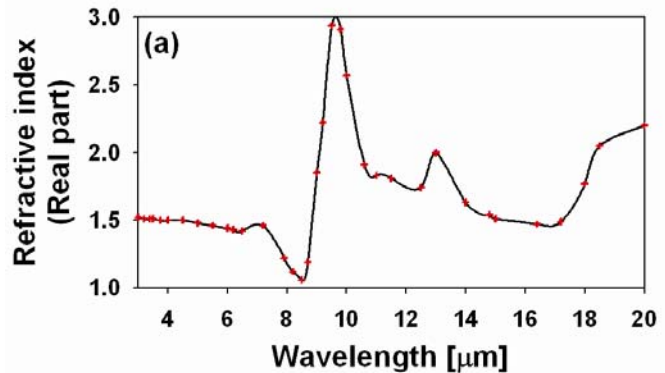
AOT,  $Z_{\text{dust top}}, Z_{\text{dust base}}$ ,  
aerosol optical properties  
( $k_a, k_s, \omega, P(\Theta), b$ )

**RTM: RTTOV-9**  
(AOPs from OPAC)

**TB simulations**

# Aerosol optical properties: refractive index

Refractive index for mineral dust in OPAC



OPAC  
refractive index

Size distribution  
(Asian dusts)

Mie  
calculation

Optical properties of  
Asian dust

$k_a$ ,  $k_s$ ,  $\omega$ ,  $P(\Theta)$ ,  $b$

# Aerosol optical properties: size distribution



## Dust observations at Dunhuang

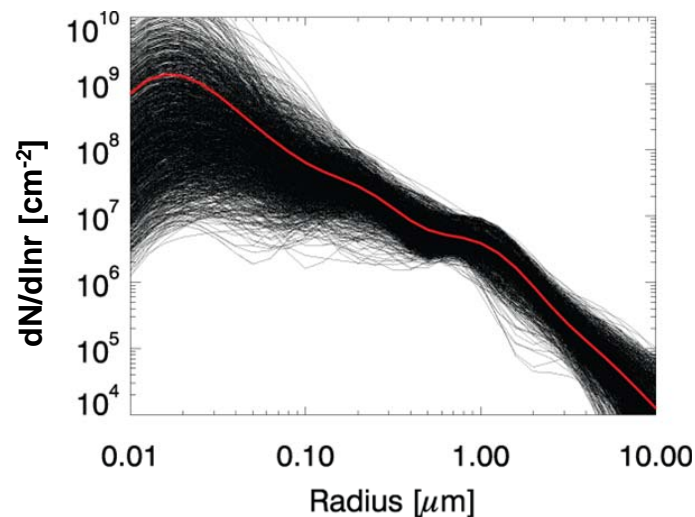
Location: 94.8 N, 40.1 E

Period: Oct. 1998 – Jan. 2007

Dust event threshold: AOT > 0.5

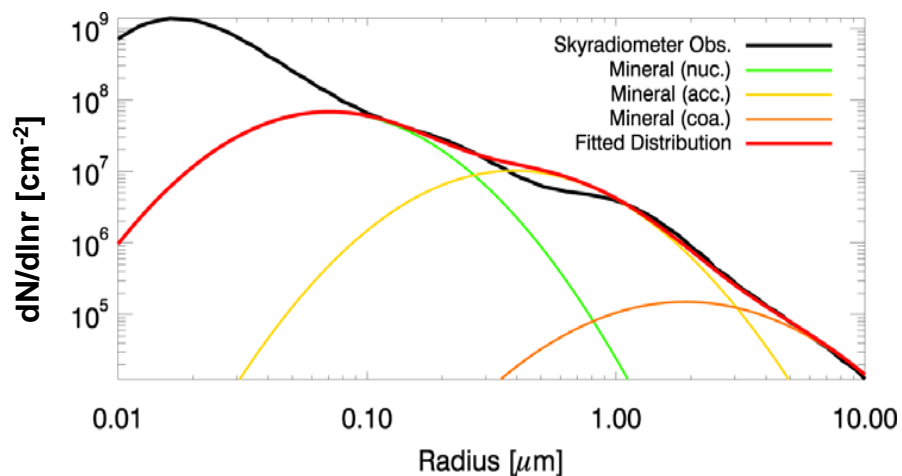
$\alpha < 0.3$

## Number size distribution



## Mineral dust modes in OPAC

- Nucleation mode
- Accumulation mode
- Coarse mode



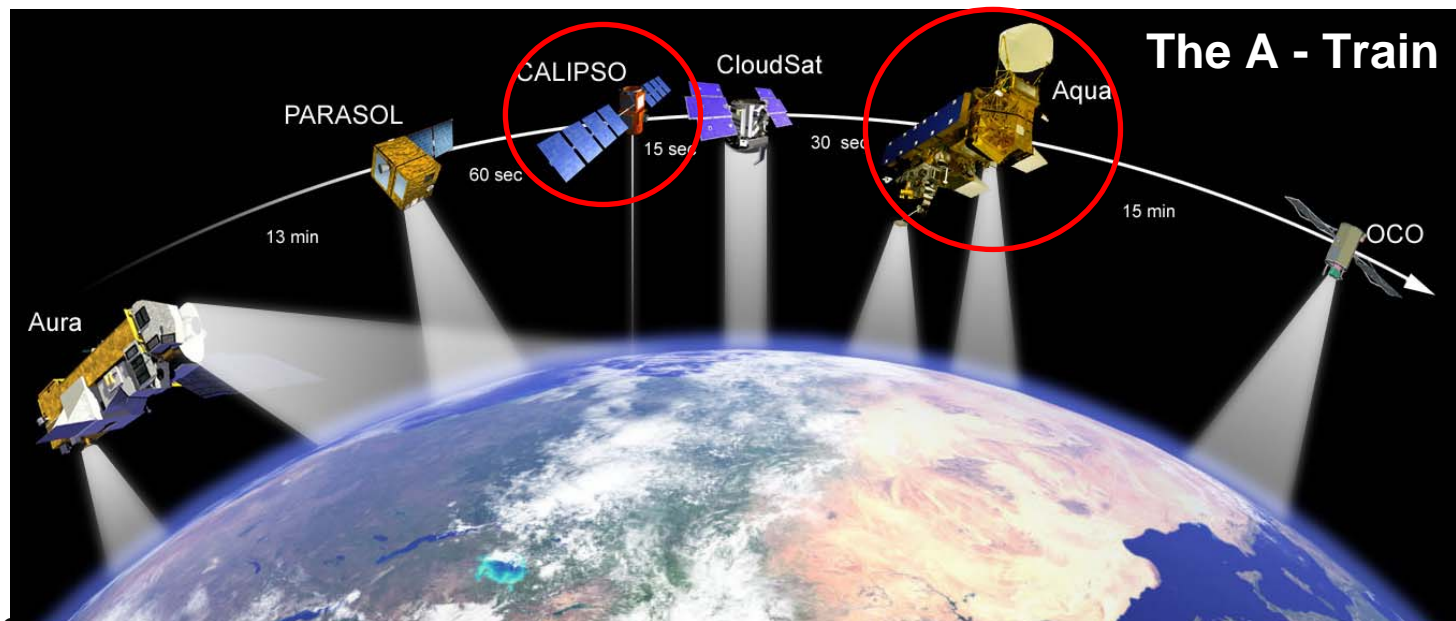
# AIRS TB simulations for dust cases

## AIRS

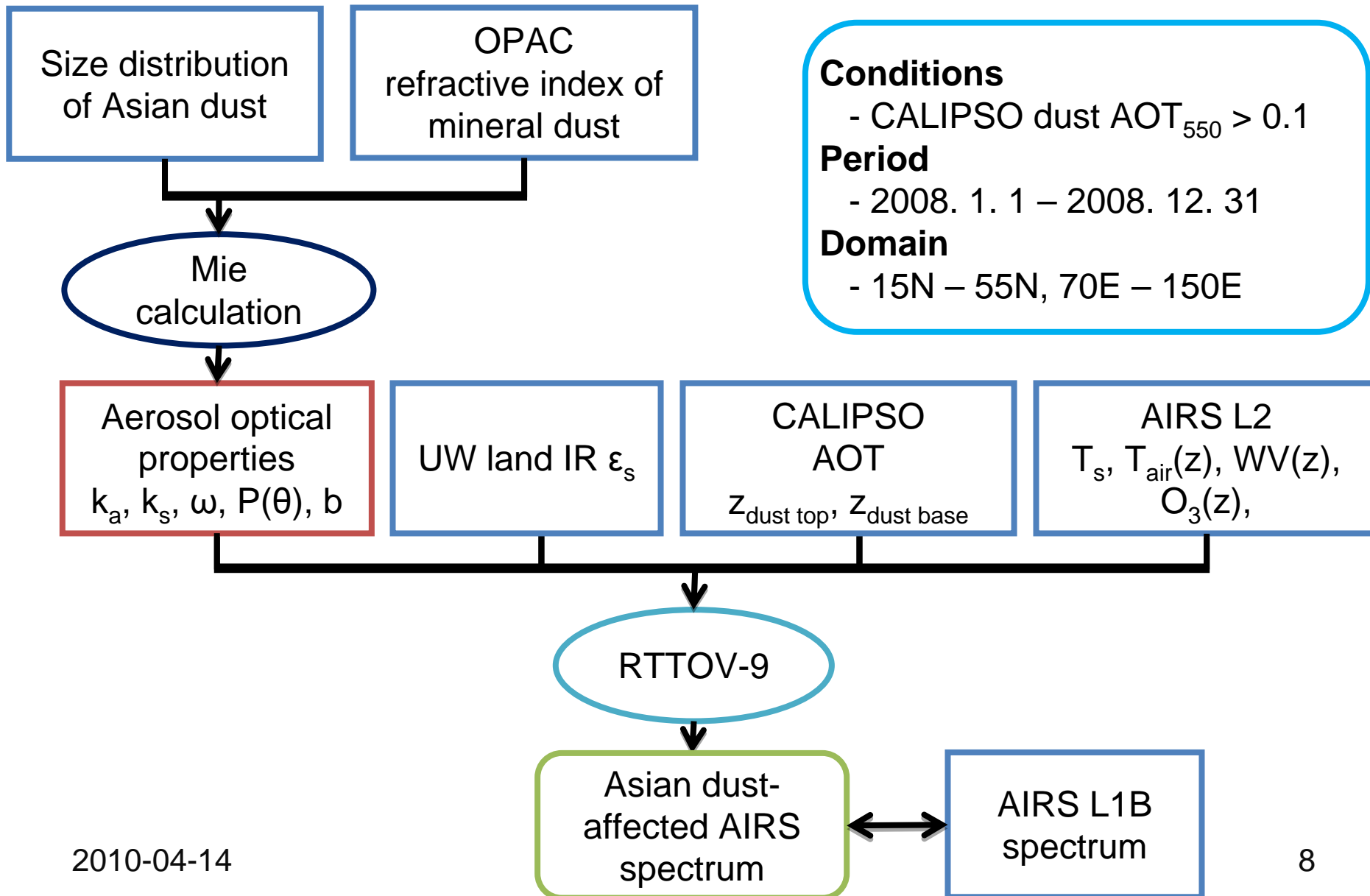
- Level 1B spectrum
- Level 2 support product:  
 $T_s$ ,  $T_{air}(z)$ ,  $WV(z)$ , and  $O_3(z)$

## CALIPSO

- AOT,  $z_{dust\ top}$ ,  $z_{dust\ base}$ , Feature Classification Flags

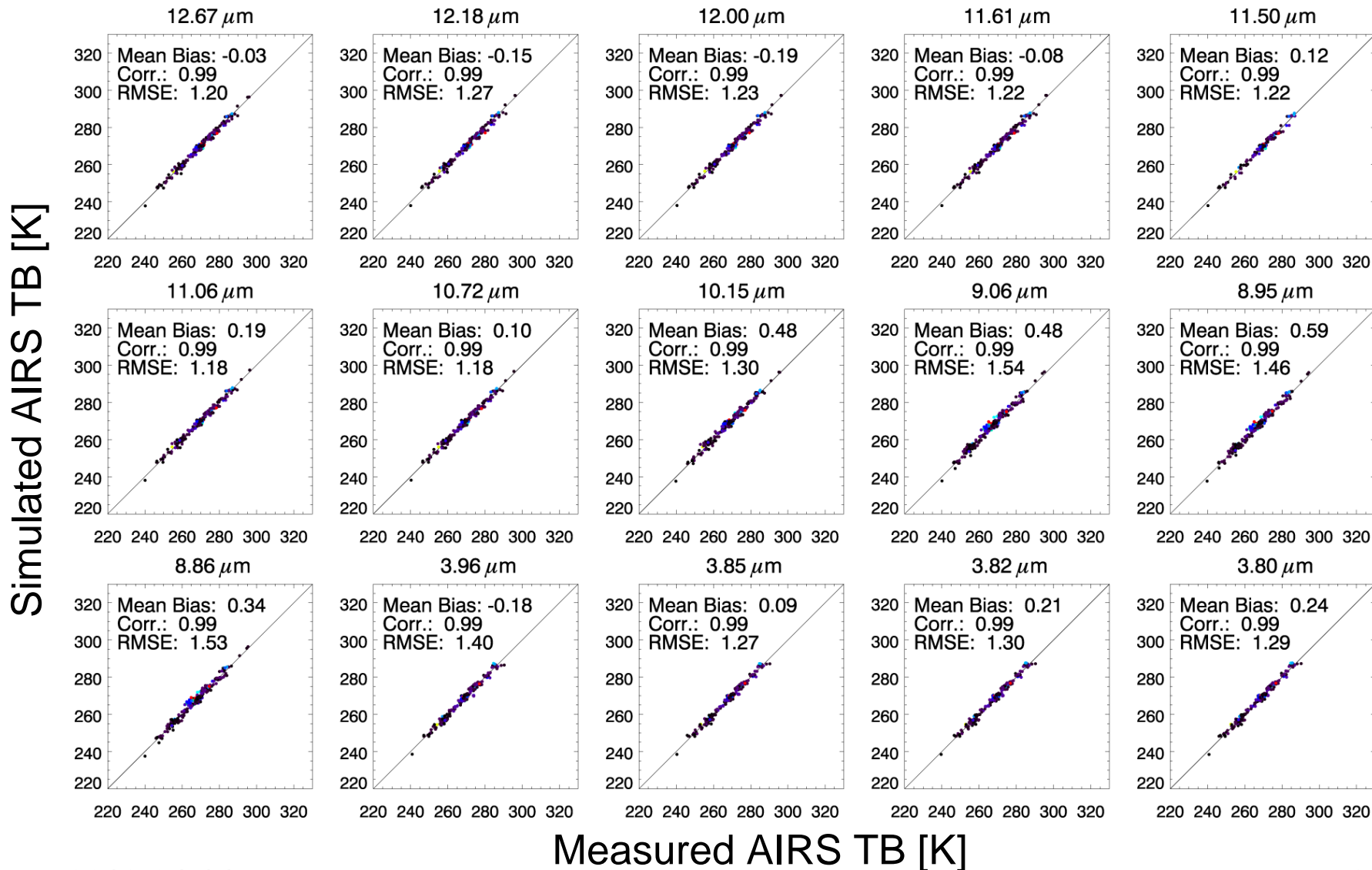


# Simulation of dust affected AIRS spectrum

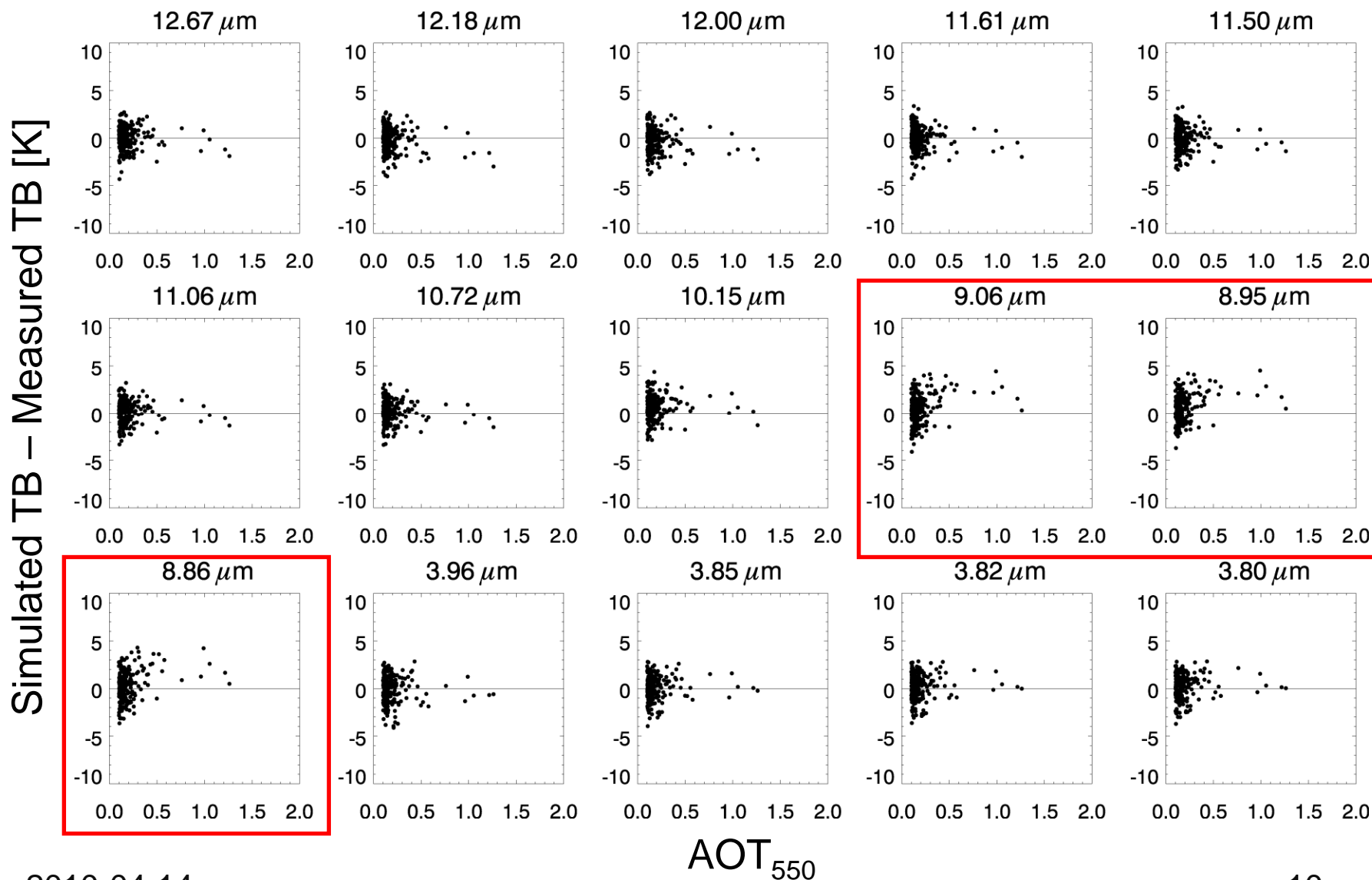




# Simulated AIRS TB vs. measured AIRS TB

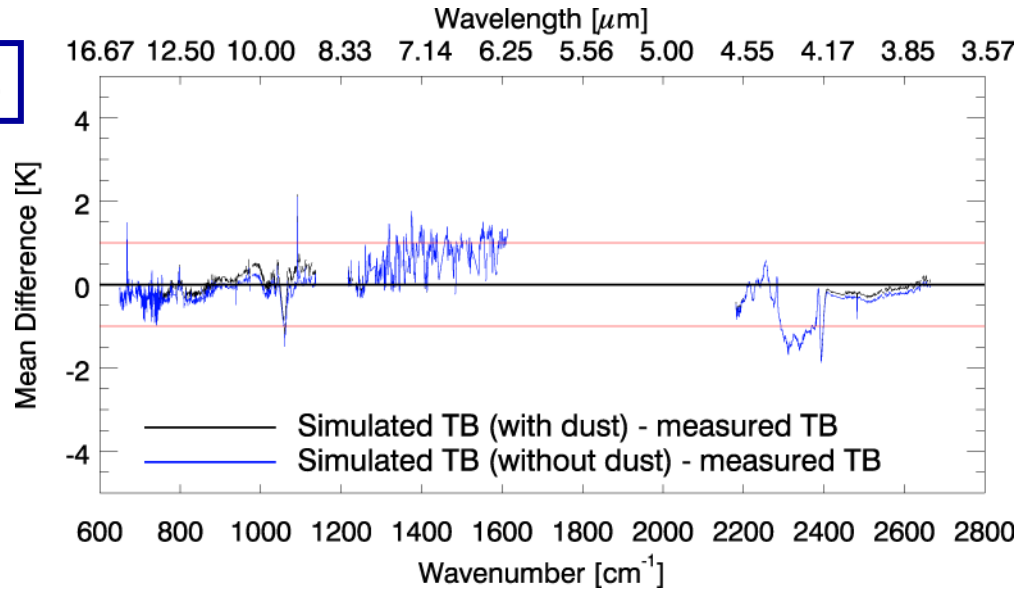


# Simulated TB – measured AIRS TB vs. AOT

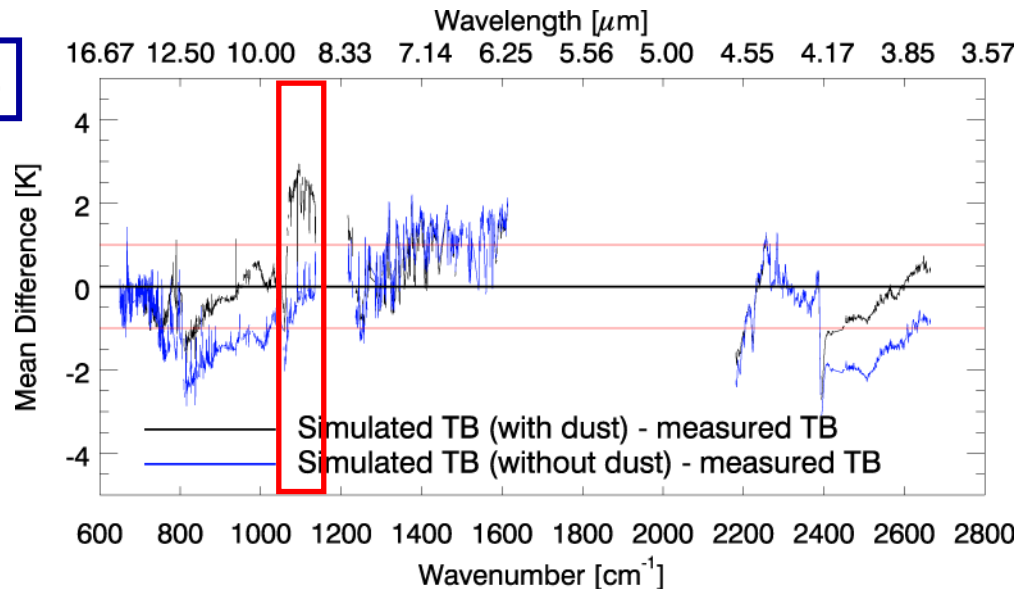


# Mean simulated TB - measured AIRS TB

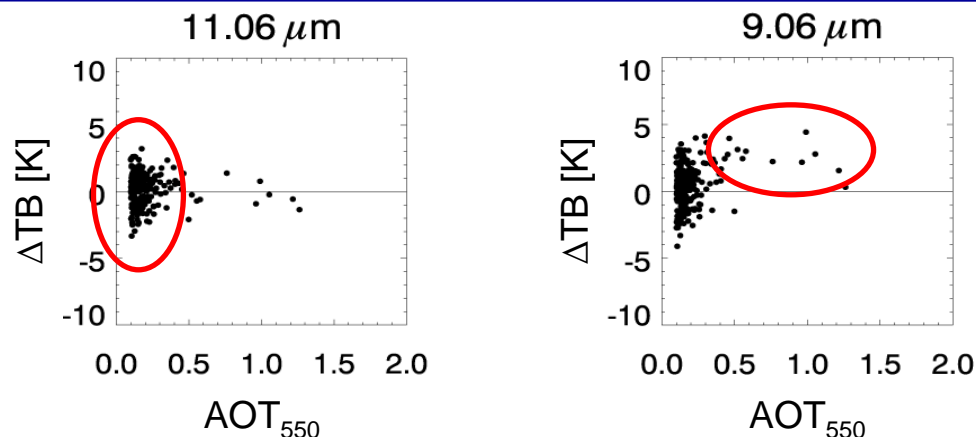
$AOT_{550} < 0.5$



$AOT_{550} \geq 0.5$



# Conclusions



- For weak dust cases, simulation errors can be occurred due to the inexact surface information.
- Results show the improved performance over spectral ranges of 10.2 – 12.7 μm and 3.8 – 4.1 μm when the dust effect was added.
- However, over spectral range of 8.8 – 9.3 μm, TB difference between simulation and measurement was increased.
- Overestimation in the range of 8.8 – 9.3 μm is probably because this spectral region is very sensitive to dust composition (Sokolik, 2002).
- It is expected that the results can be incorporated for developing dust retrieval algorithm from hyperspectral images such as AIRS and IASI.

**Thank You!**

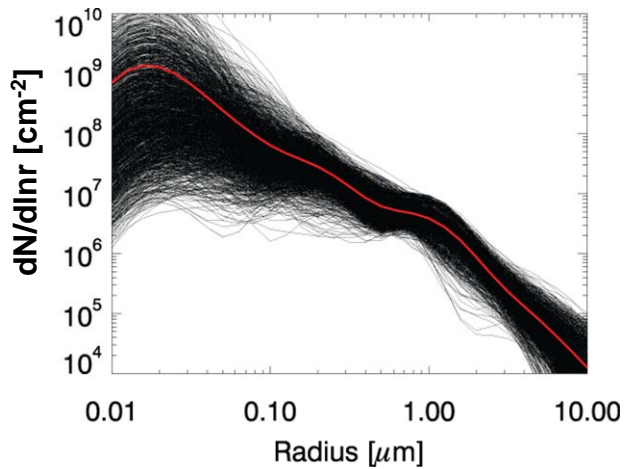
# Aerosol optical properties: size distribution

(1)

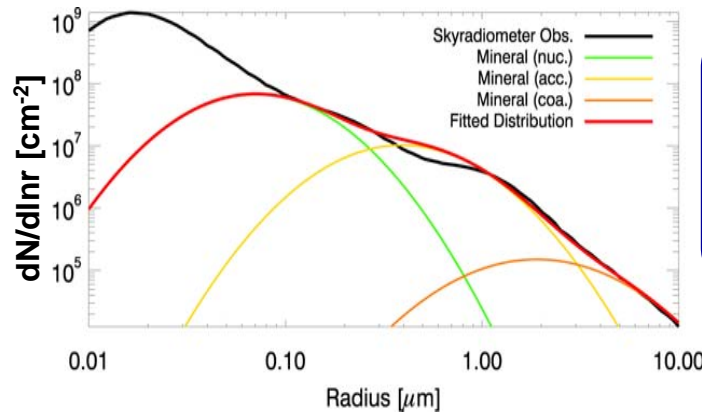


**Dust observations at Dunhuang**  
 Location: 94.8 N, 40.1 E  
 Period: Oct. 1998 – Jan. 2007  
 Dust event threshold: AOT > 0.5  
 $\alpha < 0.3$

**Number size distribution**



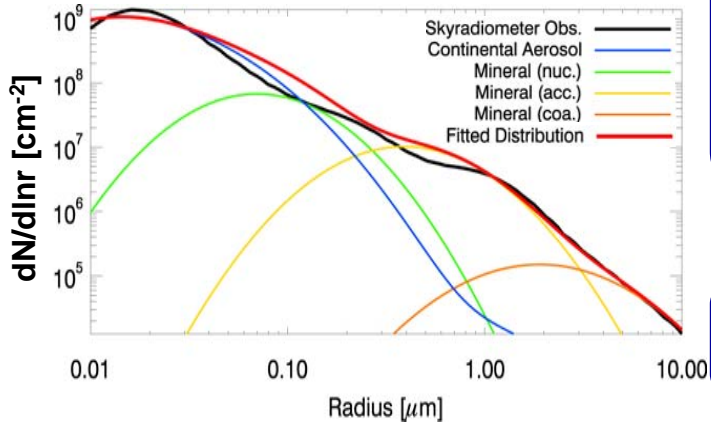
**(1) Mineral dust only**



**Mineral dust only**

- Nuc. mode
- Acc. mode
- Coa. mode

**(2) Continental aerosol added**



**Mineral dust only**

- Nuc. mode
- Acc. mode
- Coa. mode

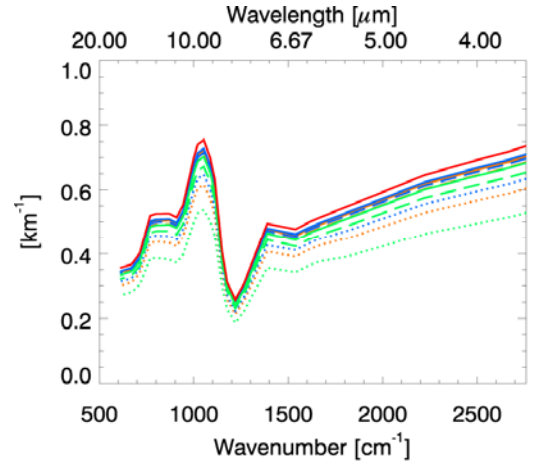
+

**Continental aerosol**

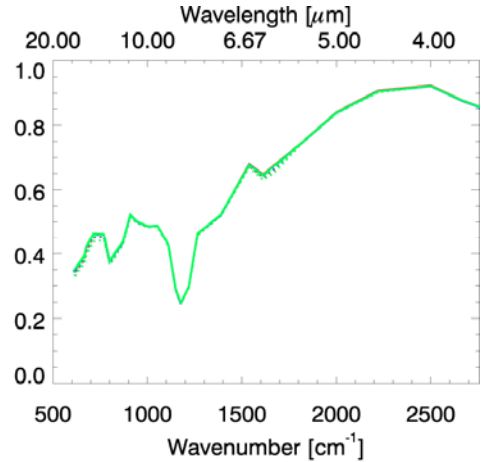
# Aerosol optical properties: size distribution

(2)

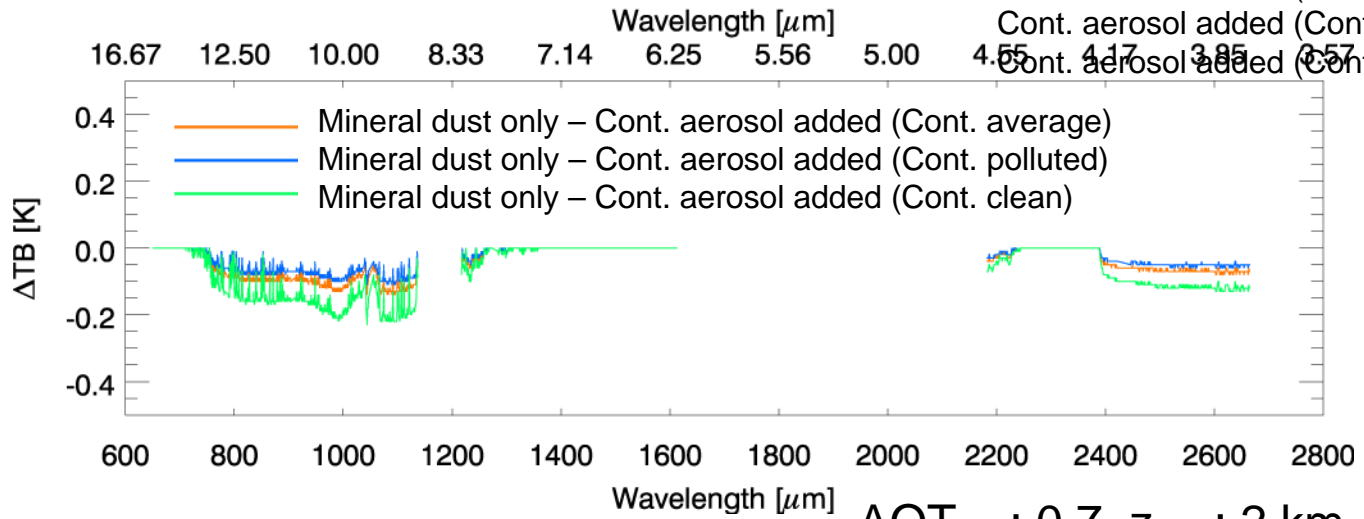
Normalized extinction coefficient



Single scattering albedo



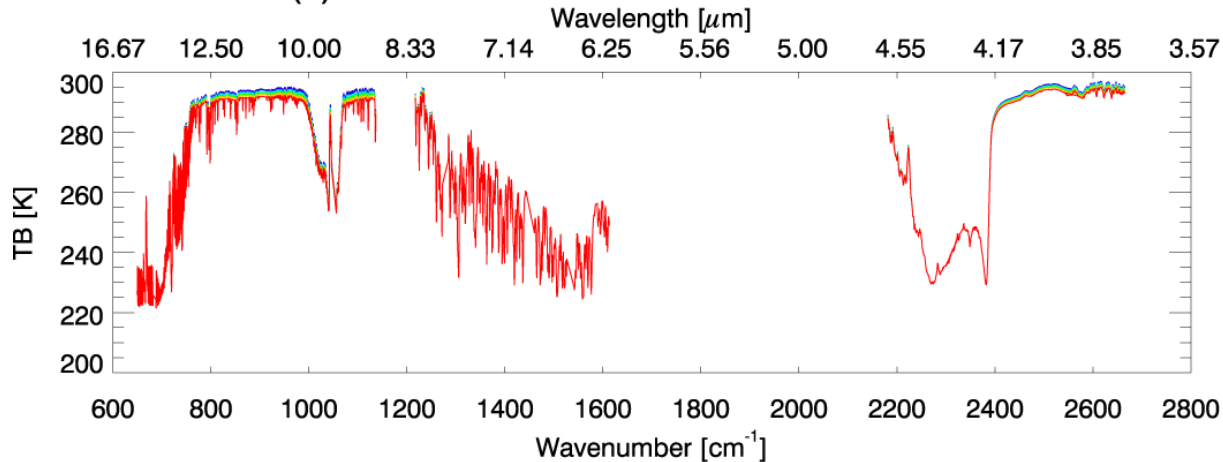
- Mineral dust only
- Cont. aerosol added (Cont. average, RH=0%)
- - - Cont. aerosol added (Cont. average, RH=50%)
- ⋯ Cont. aerosol added (Cont. average, RH=95%)
- Cont. aerosol added (Cont. polluted, RH=0%)
- - - Cont. aerosol added (Cont. polluted, RH=50%)
- ⋯ Cont. aerosol added (Cont. polluted, RH=95%)
- Cont. aerosol added (Cont. clean, RH=0%)
- - - Cont. aerosol added (Cont. clean, RH=50%)
- ⋯ Cont. aerosol added (Cont. clean, RH=95%)



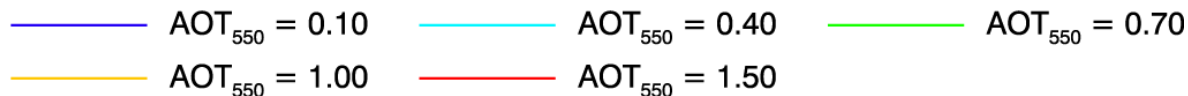
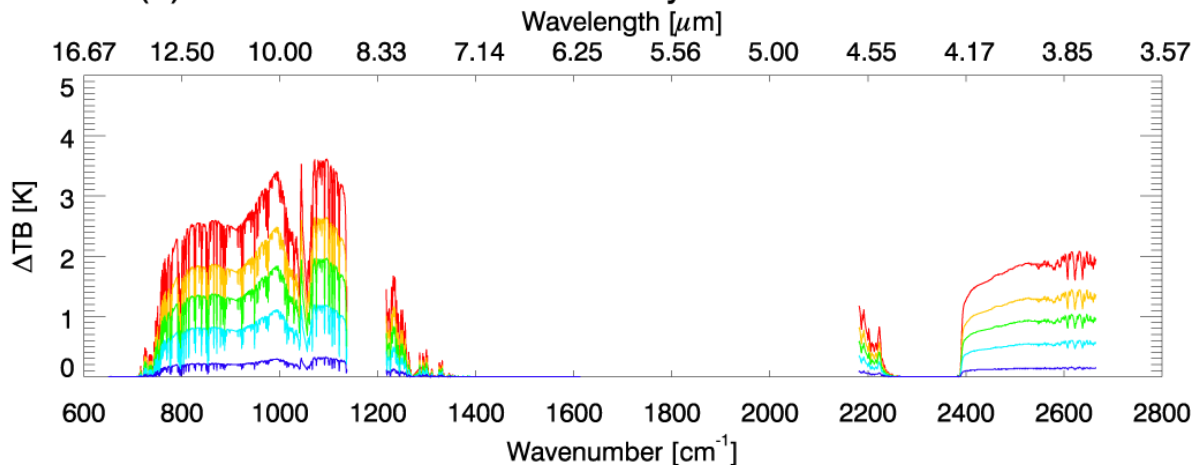
AOT<sub>550</sub>: 0.7, z<sub>dust</sub>: 2 km

# Sensitivity to AOTs

(a) Simulated TBs for various dust AOTs



(b) TB differences from clear sky for various dust AOTs

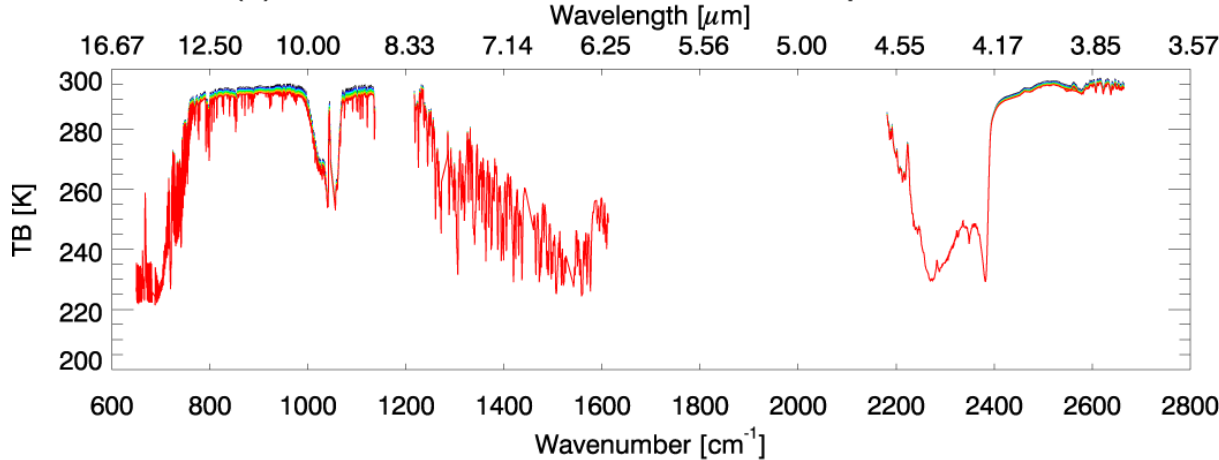


Standard atmospheric profile  
(Mid-latitude summer)  
Size distribution at Dunhuang  
Refractive index in OPAC  
A single dust layer  
 $z_{\text{dust top}} = 2 \text{ km}$   
 $\epsilon_s = 1.00$

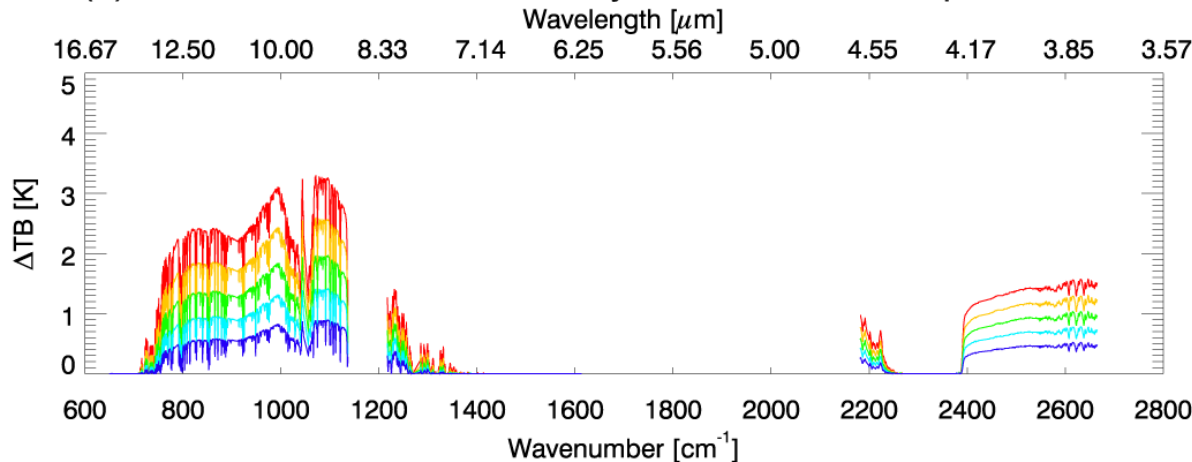


# Sensitivity to the dust top

(a) Simulated TBs for various dust top altitudes



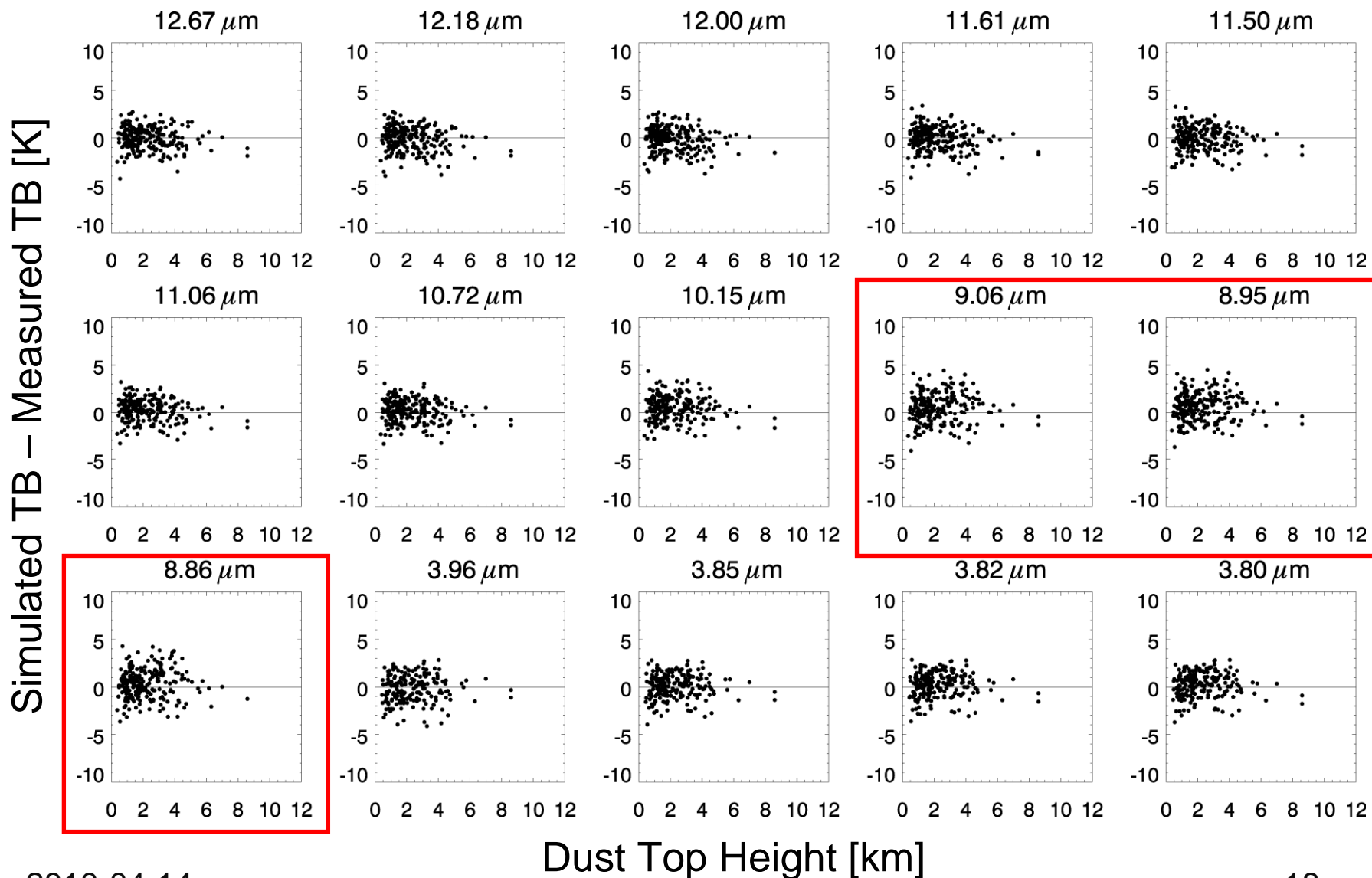
(b) TB differences from clear sky for various dust top altitudes



—  $z_{\text{dust top}} = 1.0$  km    —  $z_{\text{dust top}} = 1.5$  km    —  $z_{\text{dust top}} = 2.0$  km  
—  $z_{\text{dust top}} = 2.5$  km    —  $z_{\text{dust top}} = 3.0$  km

Standard atmospheric profile  
(Mid-latitude summer)  
Size distribution at Dunhuang  
Refractive index in OPAC  
A single dust layer  
 $\text{AOT}_{550} = 0.7$   
 $\epsilon_s = 1.00$

# Simulated TB – measured AIRS TB vs. Dust top



# Skyradiometer measurements at Dunhuang

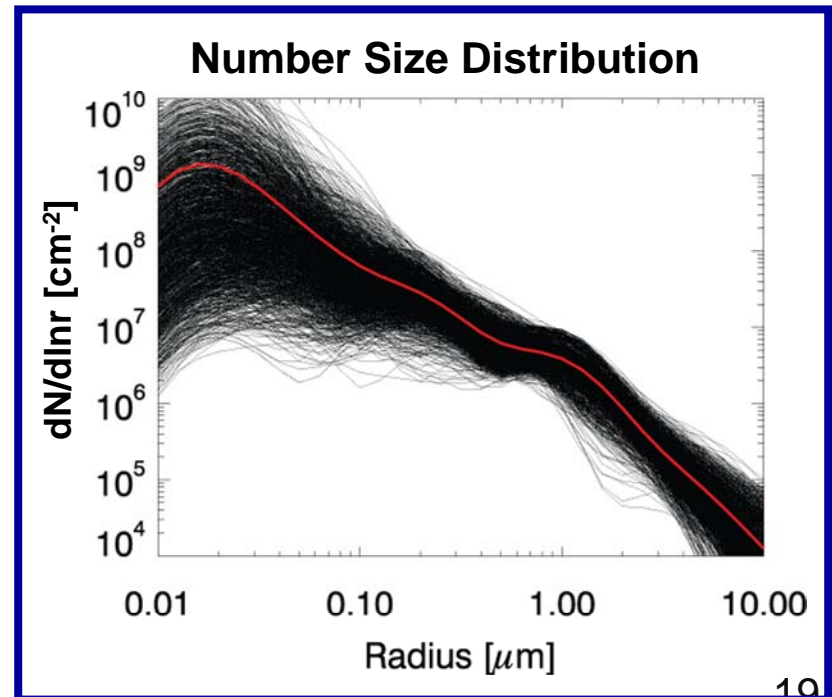
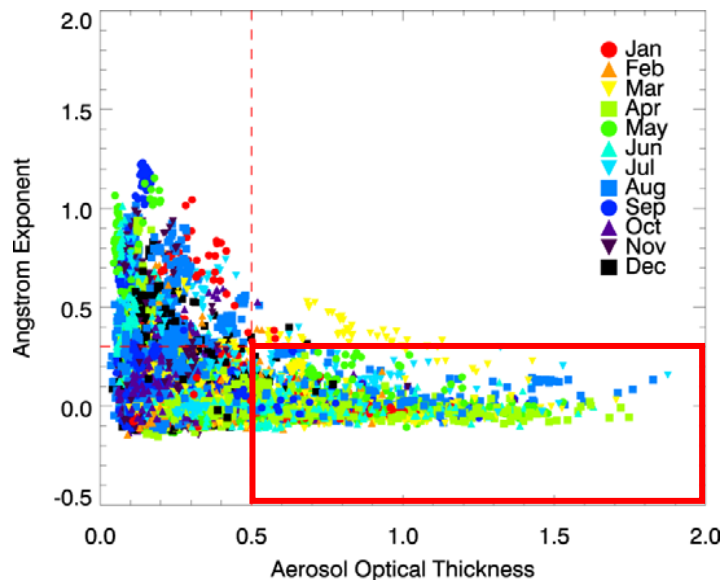


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Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,  
Cooperative Institute for Meteorological Satellite Studies, 2011.