Retrieval of aerosol microphysical and chemical properties in heavy haze days, China

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Near 2008 Olympic game stadium.

Contents

Haze in China

AOD(440nm) = 0.25

AOD(440nm) = 1.8

Pictures taken from CE318 station on the roof of IRSA building, Beijing.

Haze day numbers increasing tremendously in china

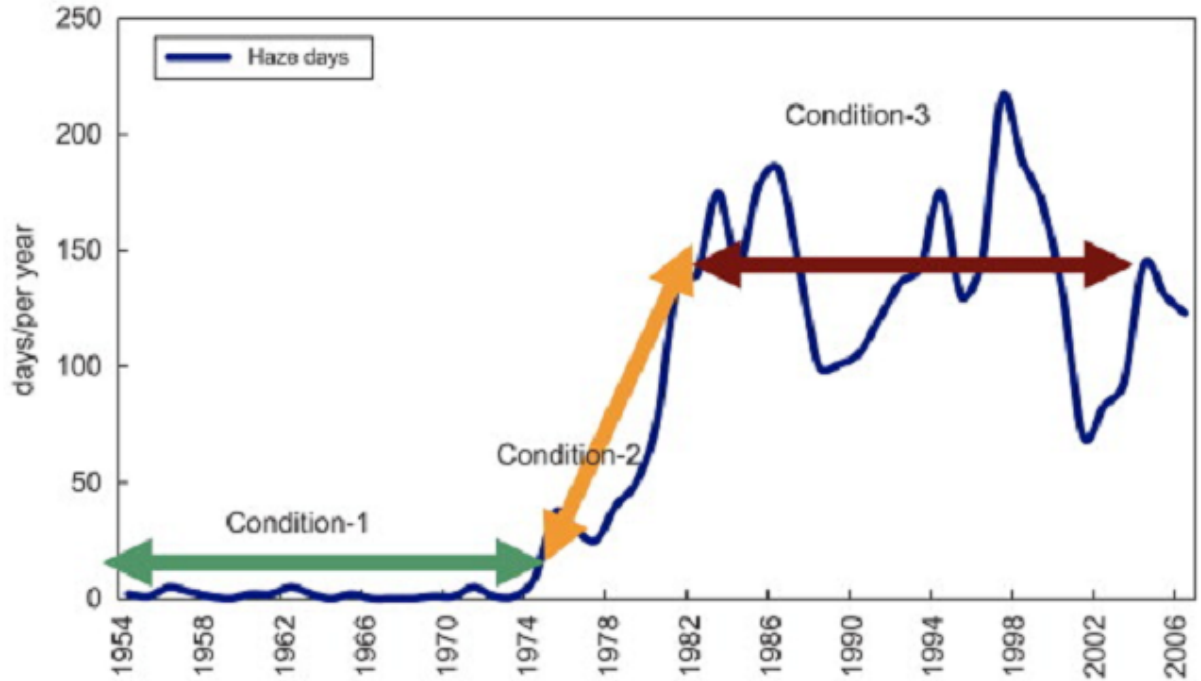


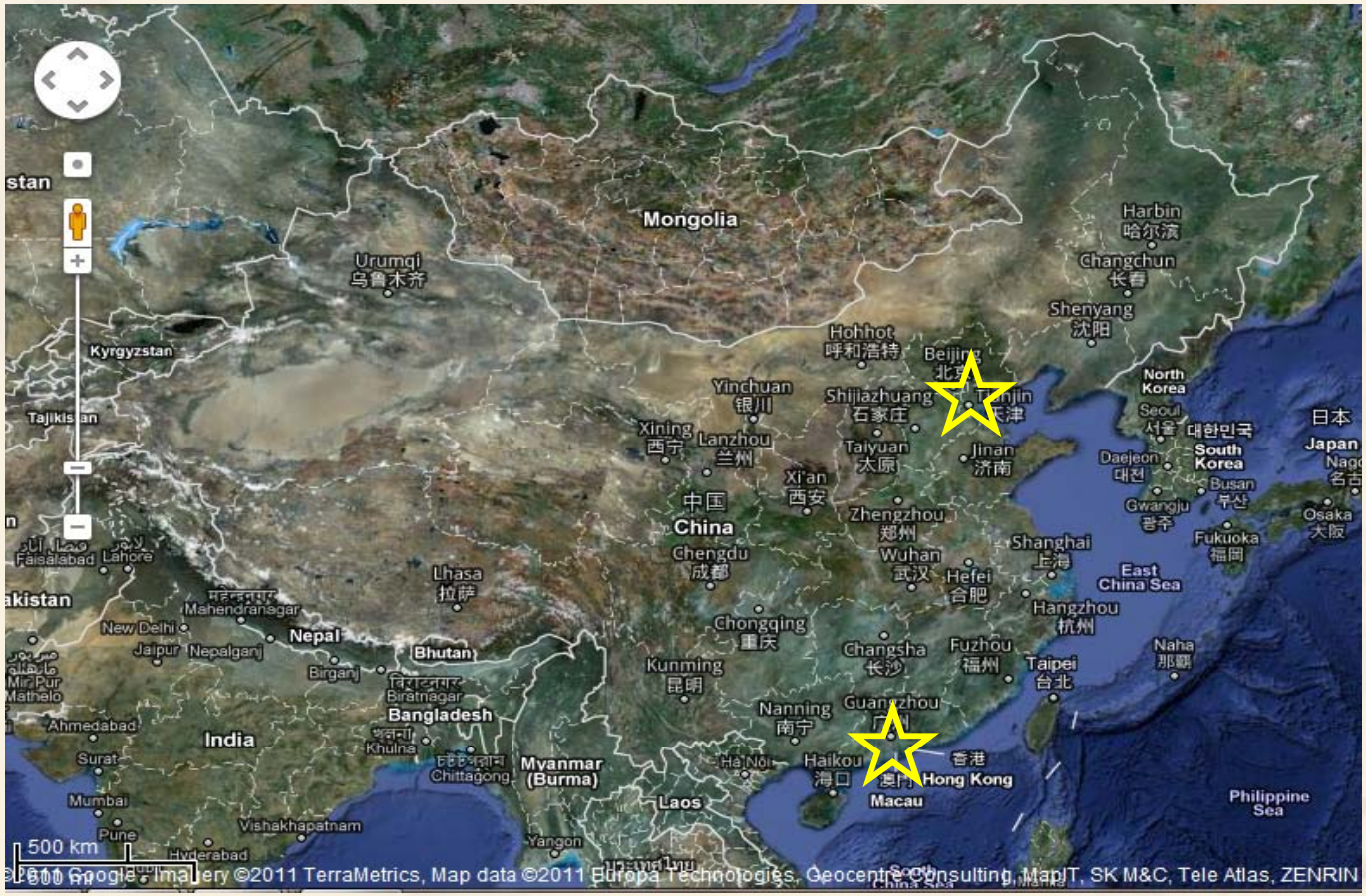
Fig. 1. A 52-year observation of haze day occurrences in Guangzhou. The haze day is defined by a combination of the following conditions: (a) daily mean visibility is <10 km; (b) daily mean relative humidity (RH) is <90%; and (c) there is no precipitation (Wu, 2005).

Deng et al. (2008) Atmospheric Environment, 42, 1424-1435 doi:10.1016/j.atmosenv.2007.11.025

Heavy haze often under cloud and complex interaction with clouds

--- Affect regional climate and precipitation significantly.

Two most economical regions in north and south China selected --- How about difference on their haze situation?



North – Beijing; South Zhongshan (near Guangzhou)

Approach:

Sun-sky Radiometer

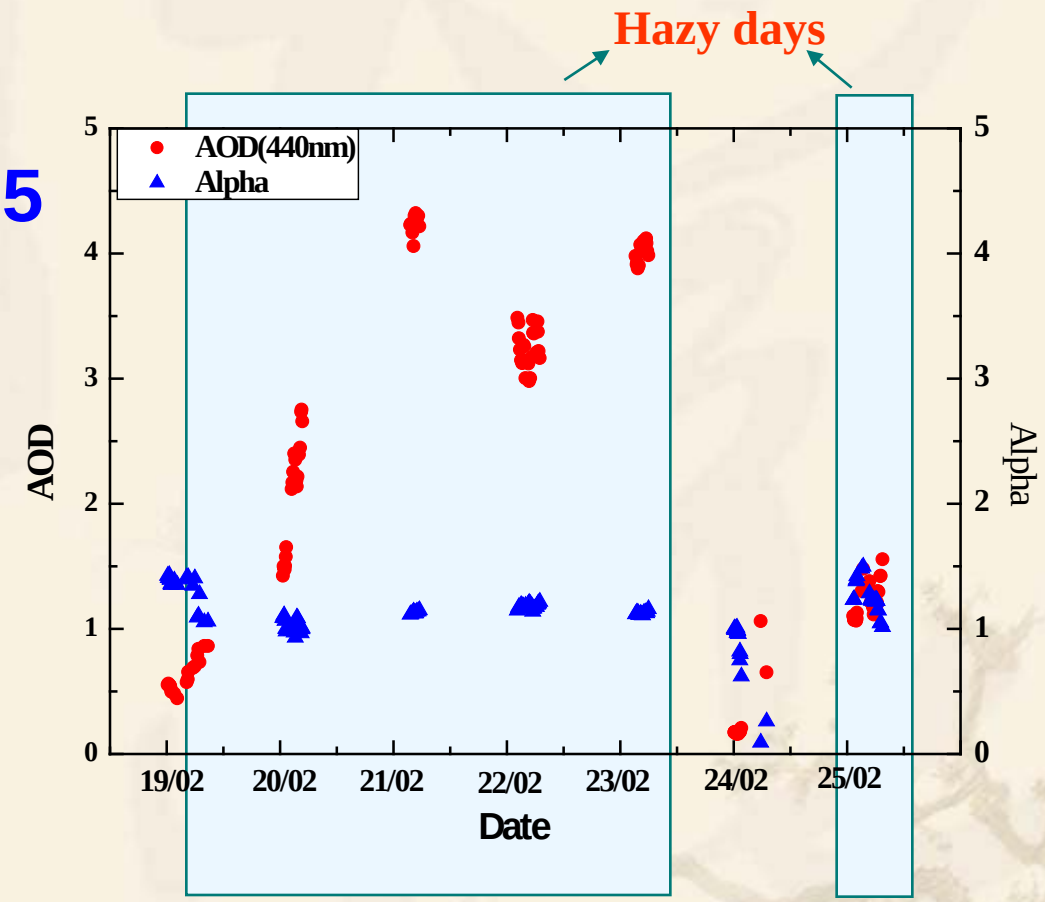
Methods

1. Optical selection criteria for Haze

(1) **AOD (440nm) > 0.5**
(Visibility<10km,Bäumer,et al,2008,AE)

(2) **RH% < 90%**(wu,2005)

(3) **Alpha > 1.0**(not dust)



Heavy haze:

AOD(440nm) > 1.5

Applied to Beijing measurements in Feb 2011.

Calibration – Vicarious method

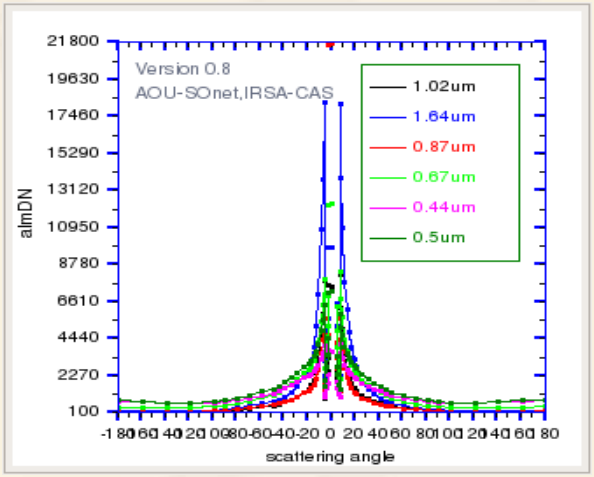
Linked to AERONET calibration

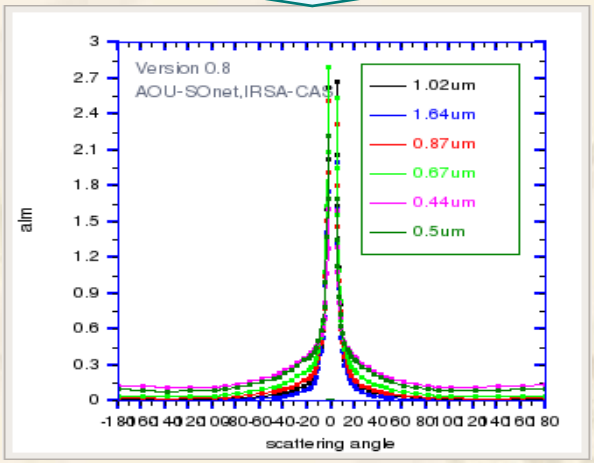
V0 => $$L'(\lambda,\Theta) = \frac{\pi g(\lambda)}{\Omega_v V_0(\lambda) f_{es}} V_a(\lambda,\Theta)$$ **=>**

(Li et al., jqsrt, 2009)

Transferring high accurate V_0 (direct sun) calibration directly to sky radiance measurements based on constant properties of CE318 viewing solid angle.

Raw DN counts





Normalized Radiance

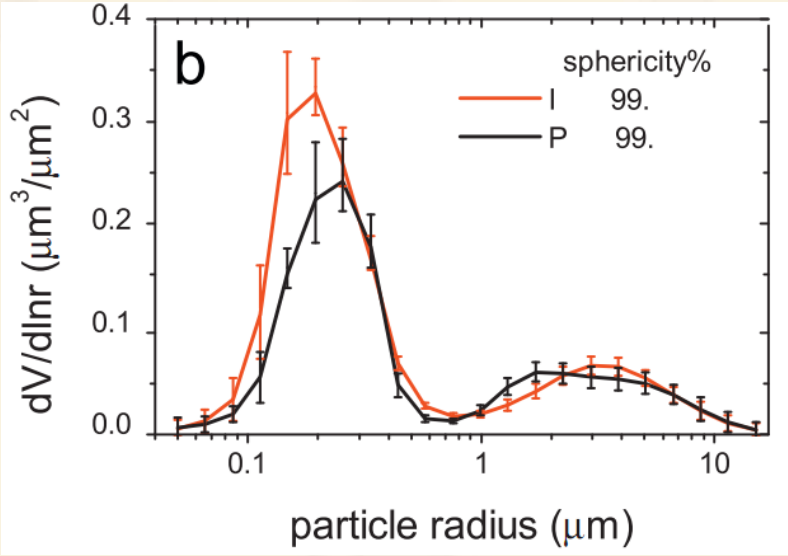
Retrieval – Aerosol optical & microphysical properties

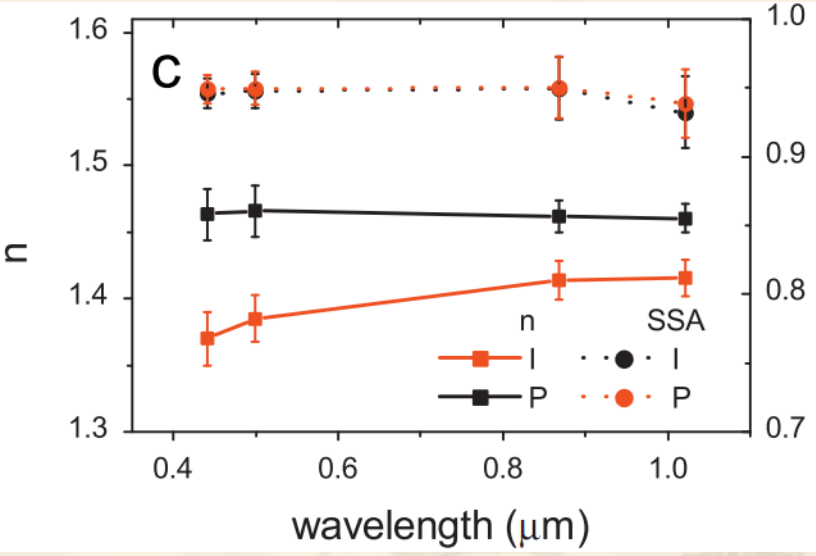
- Dubovik algorithm

(Dubovik et al., 2000; 2006)

Applied to take into account polarization measurements

(Li et al., jqsrt, 2009)

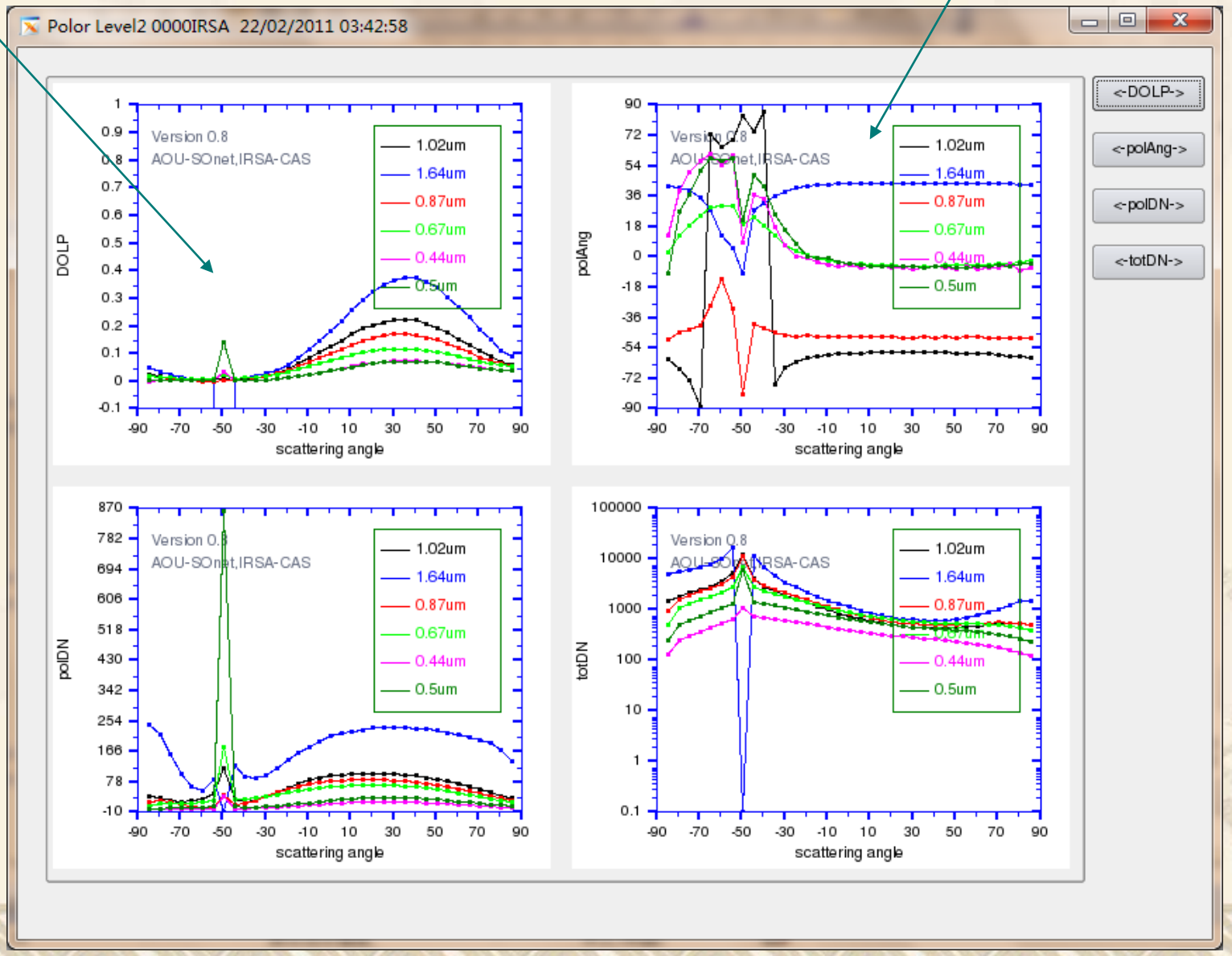




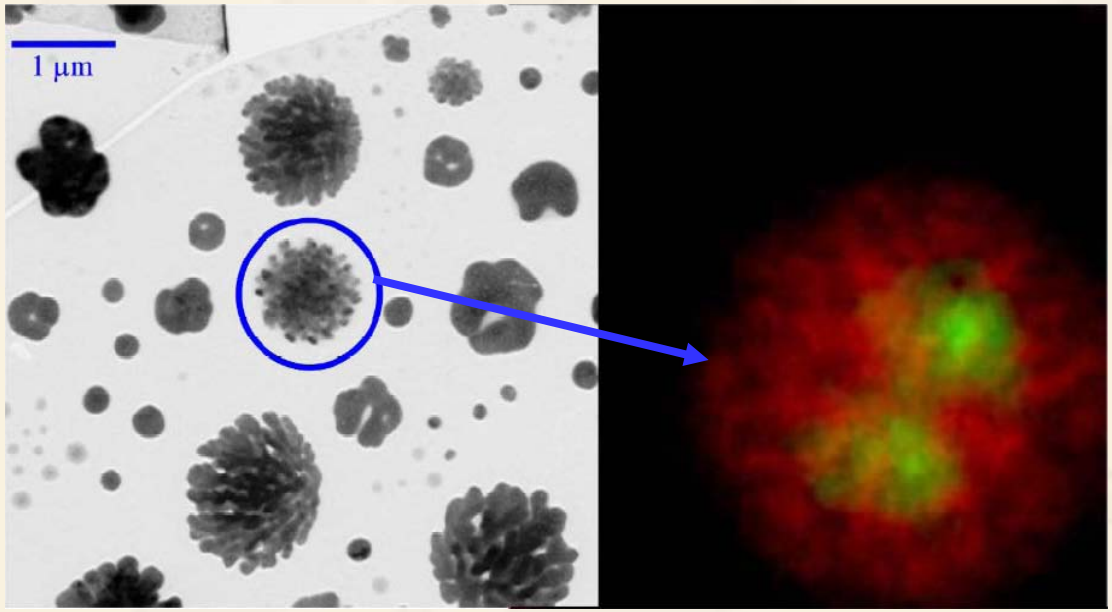
Correcting possible bias by constraining simultaneously DOLP measurements.

Multi-wavelength DOLP

Polarization angle

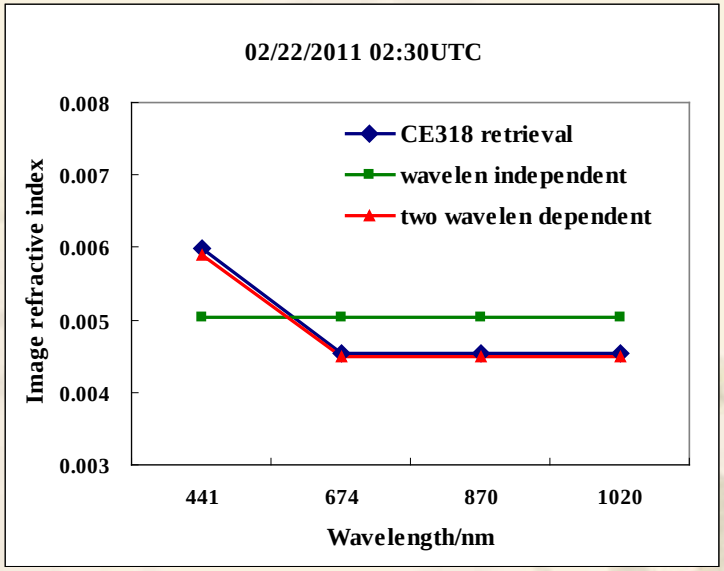


Retrieval – Chemical components



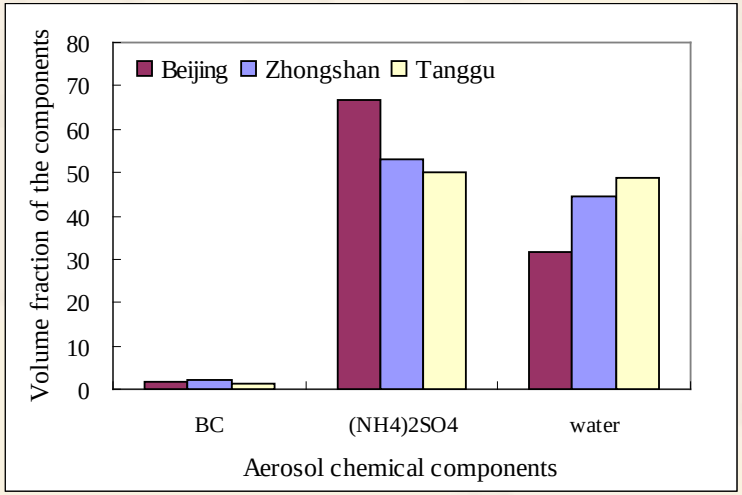
(Nguyen, 2007)

Improving Schuster's scheme by considering spectral variation (UV and NIR) of imaginary part of refractive index.

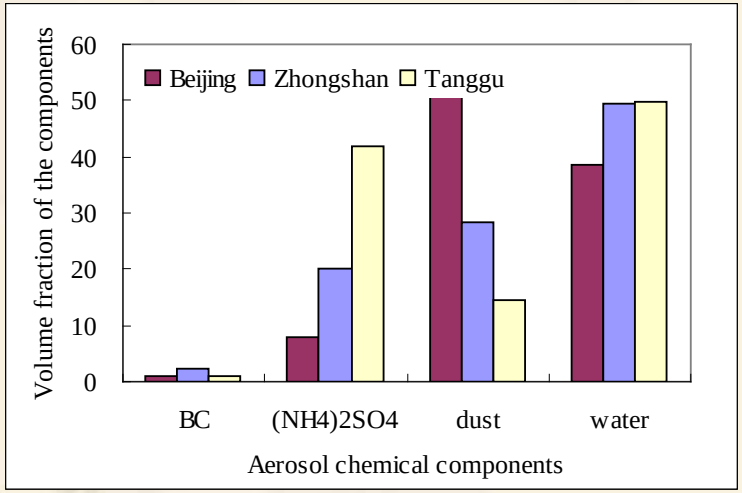


Estimating 4 components

(Schuster scheme)



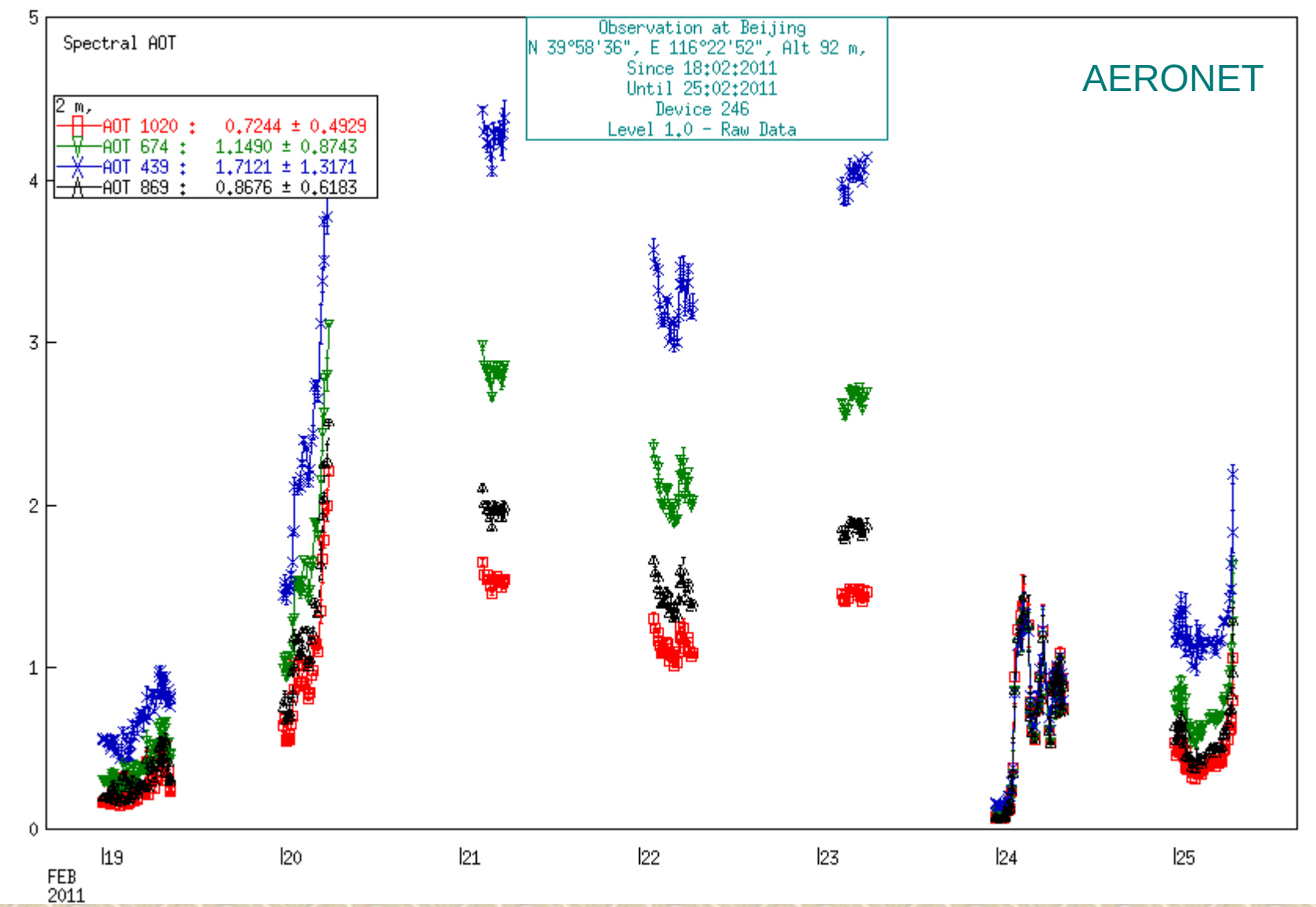
(New)



- **Black Carbon**
- **Ammonium sulphate**
- **Mineral dust**
- **Water**

Observation in haze days

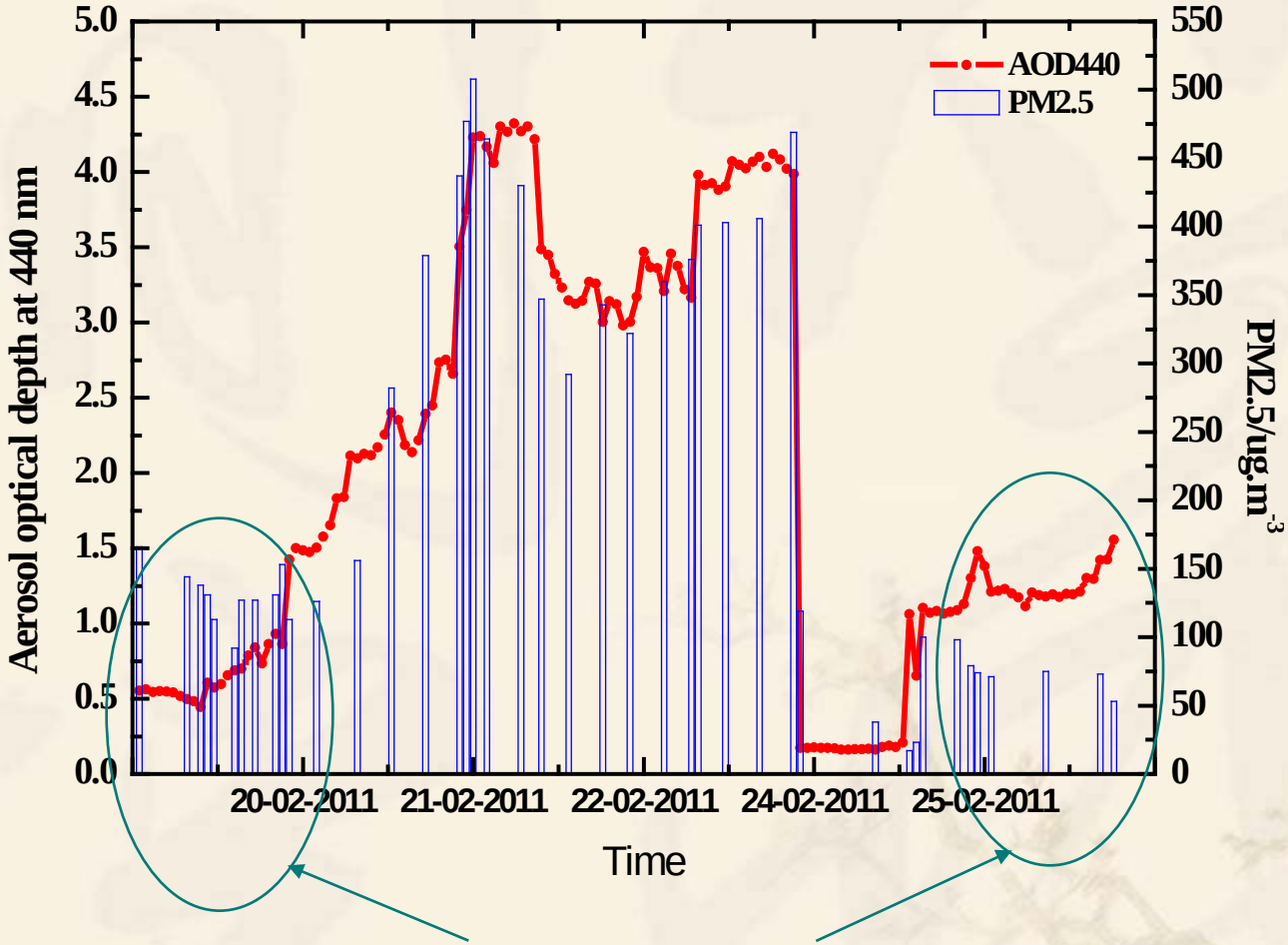
A heavy haze event at Beijing (Feb 20-23, 2011)



Feb 22, 2011

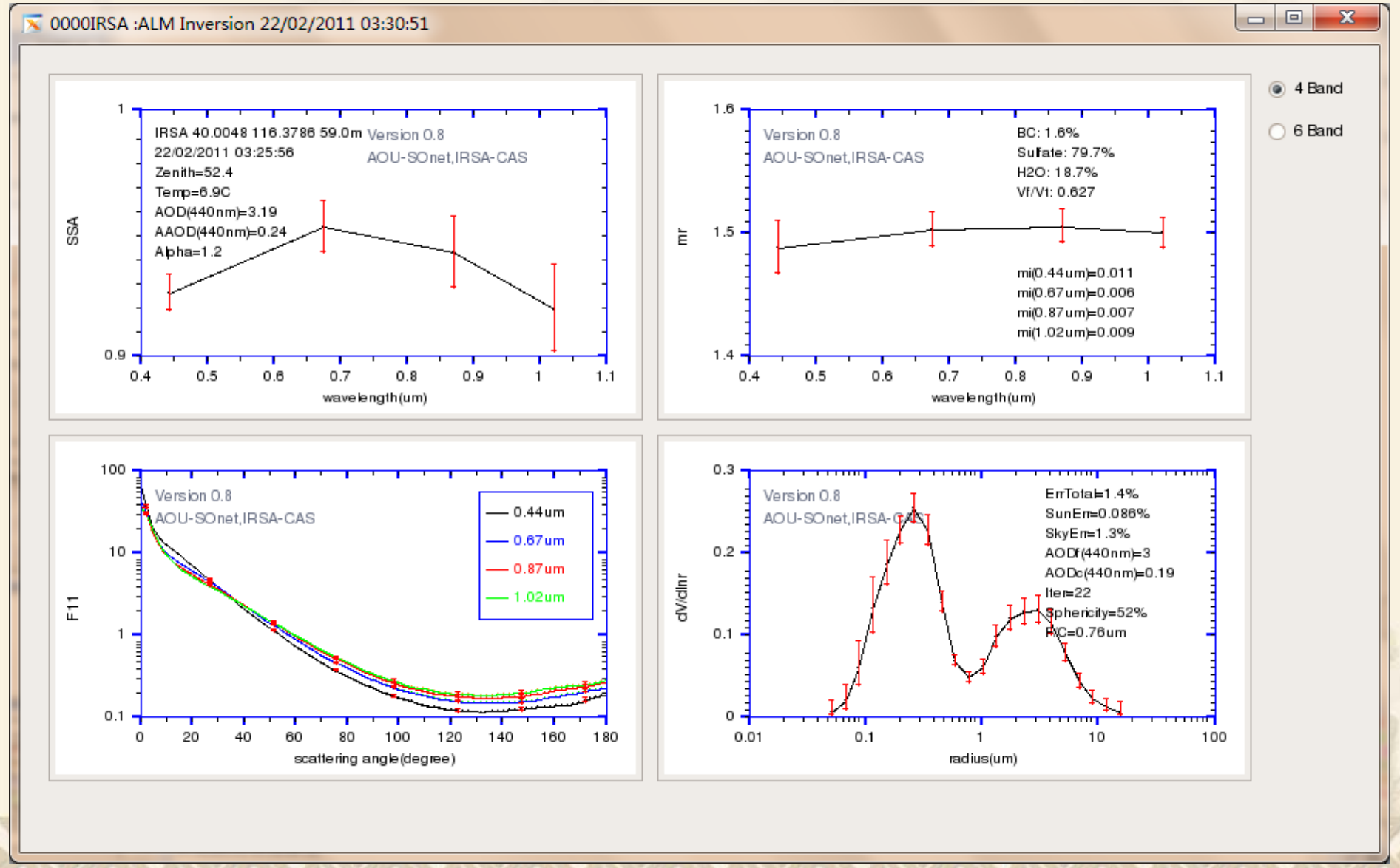
IRSA CE318 Station.

Consistency with PM observation at Beijing

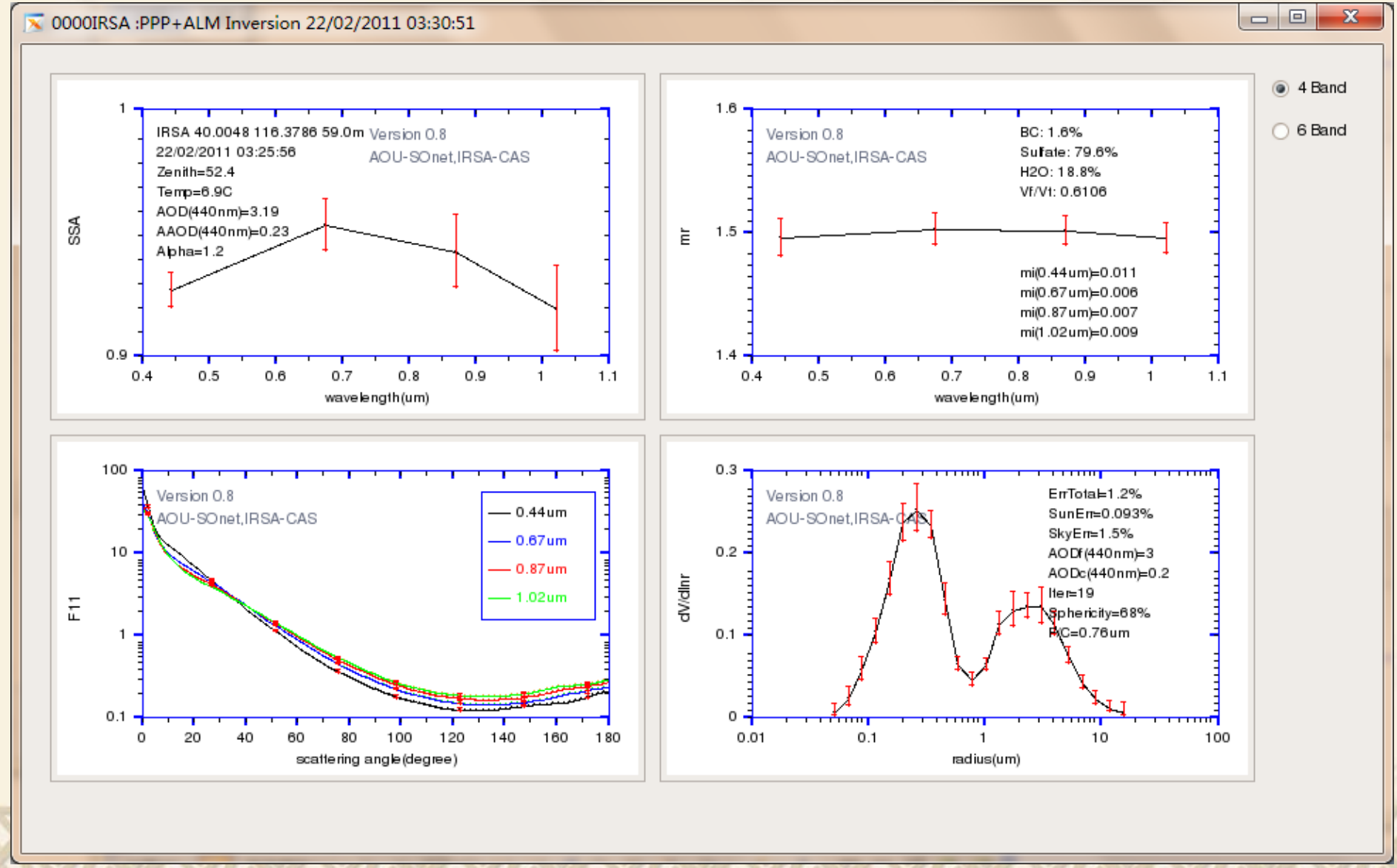


Slight haze has different PM-AOD relationship compared with heavy haze!

Heavy haze retrieval (22/02/2011) 3:30



Retrieval including polarization (Alm radiance + Spp DOLP @ 4 wv)



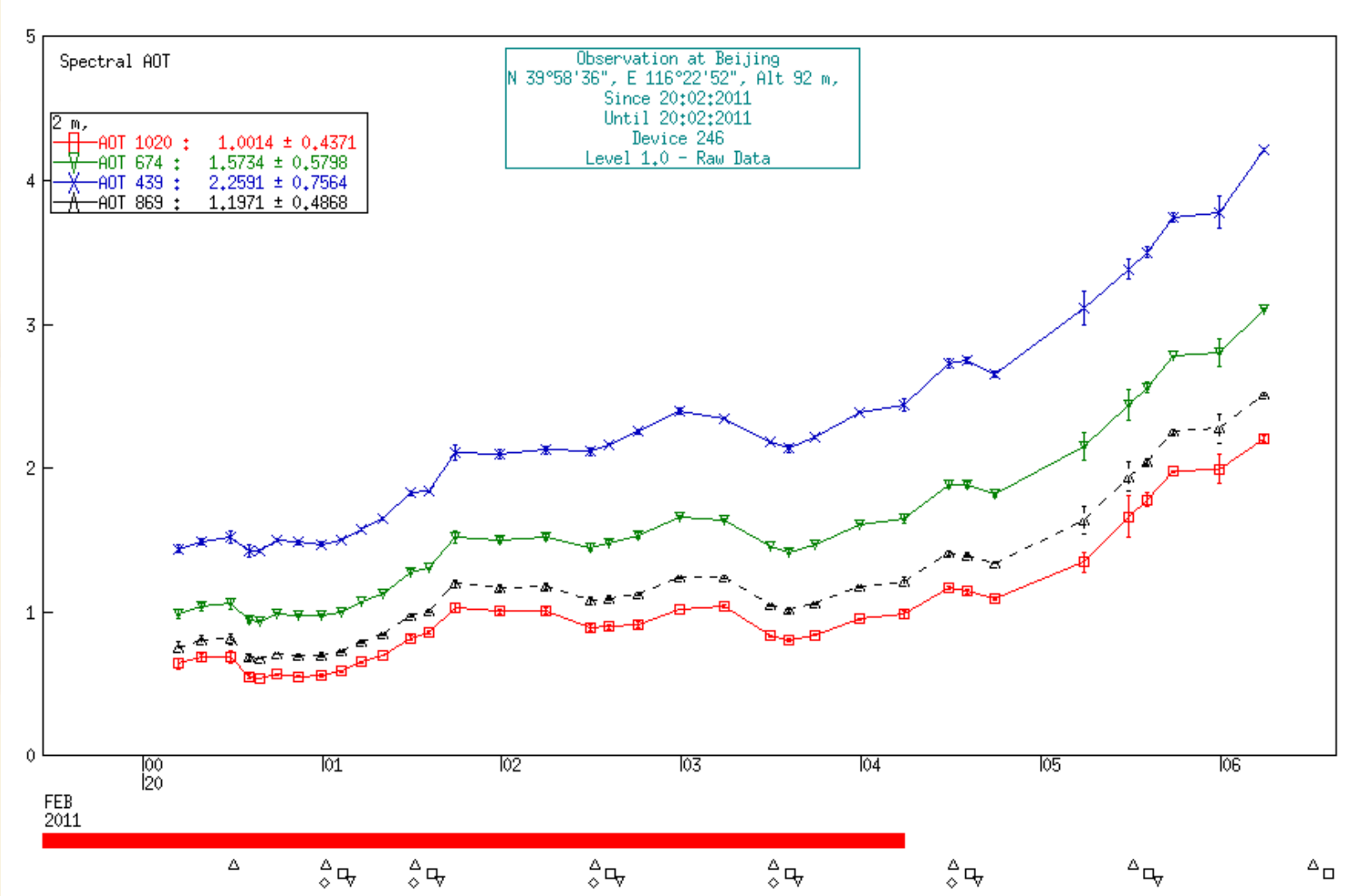
Summary on haze measurements

(1) In such a high level aerosol content, we have strong confidence for the optical, microphysical, even chemical retrieval results from sun-sky radiometer measurements.

(2) Additional spectral and angular measurements of degree of linear polarization (DOLP) measurements used in the polarization, confirm again the retrieval results.

Analysis and Conclusion

1. Formation (20/02/2011)

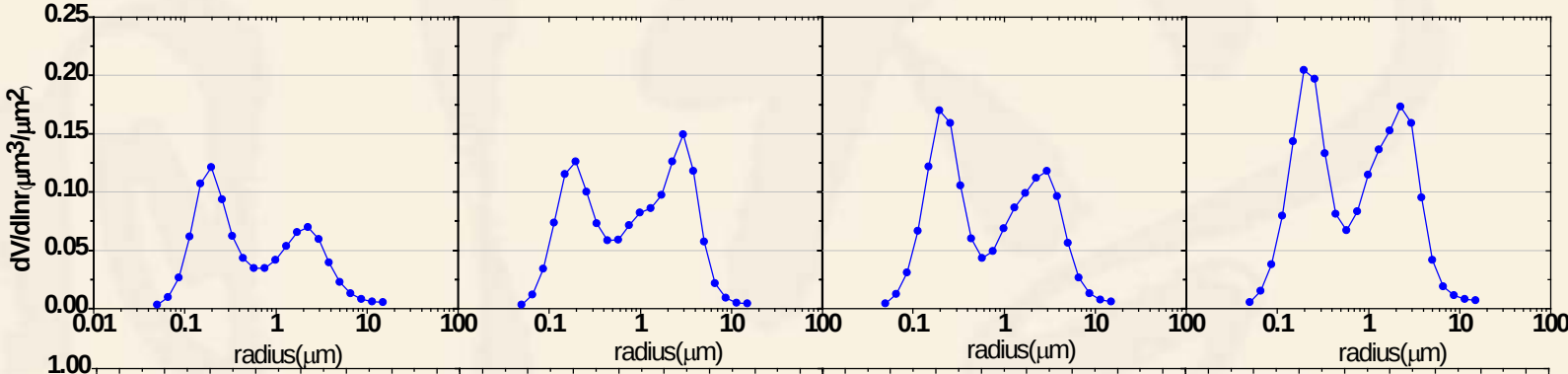


AOD(440nm): 1.5 – 4.2, from moderate haze to heavy haze

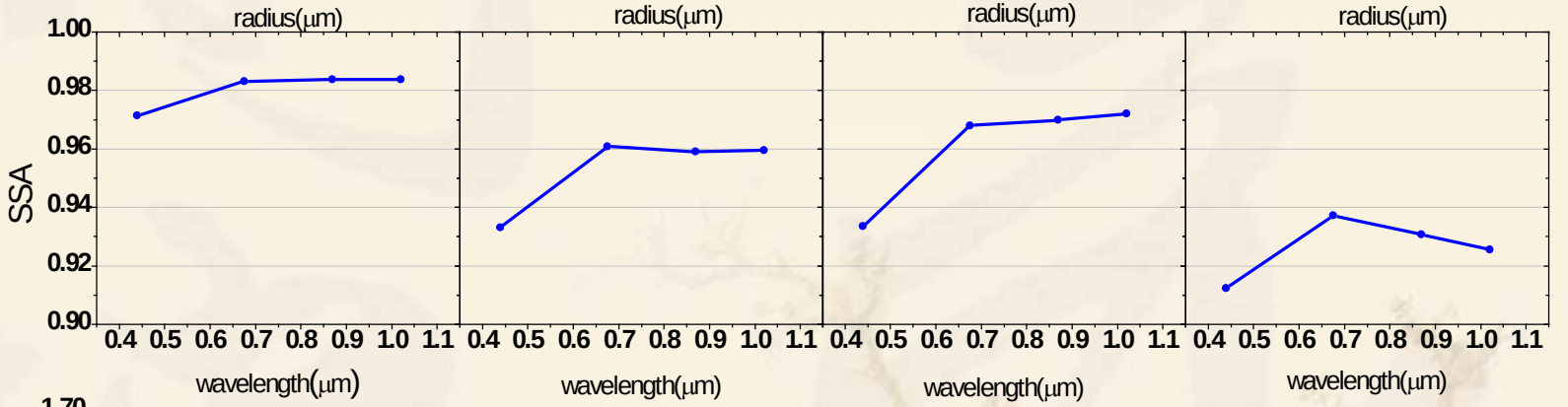
Variation of haze properties (feb.20)

AOD1.5 → AOD1.8 → AOD2.2 → AOD2.5

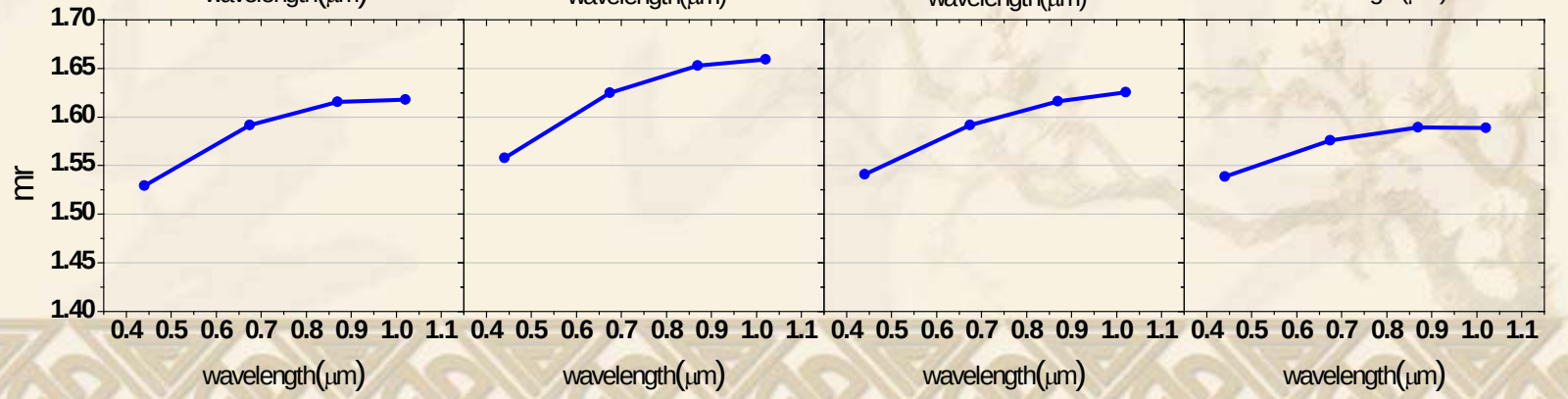
Size distribution



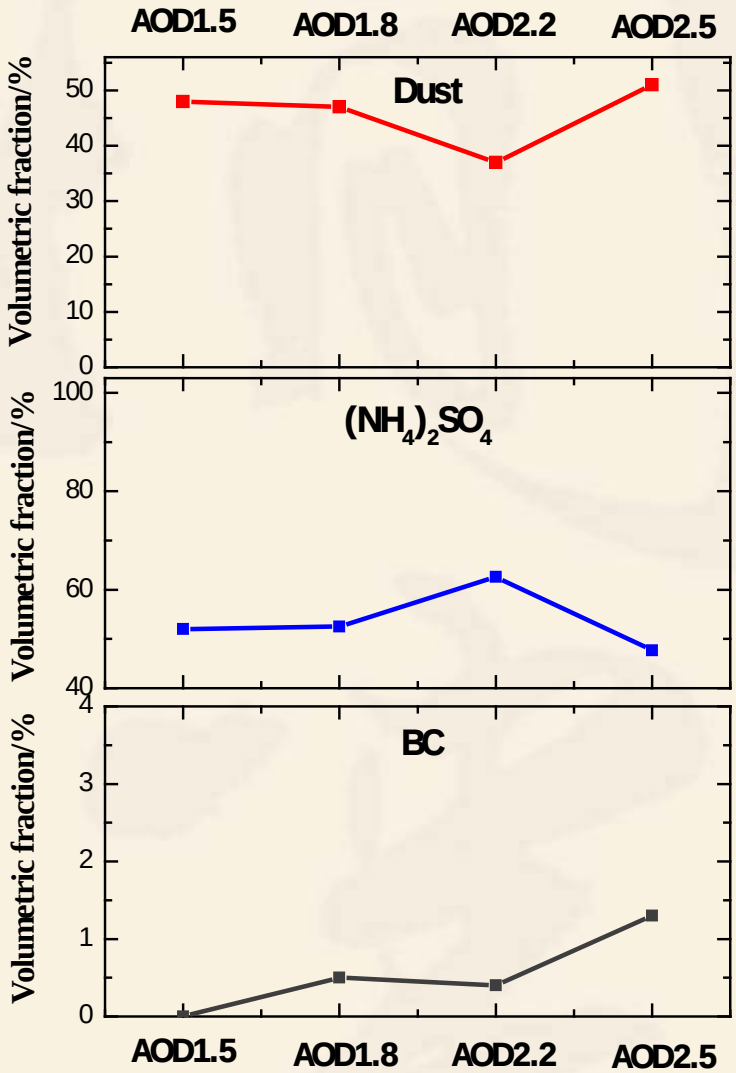
Single scattering albedo



Refractive index



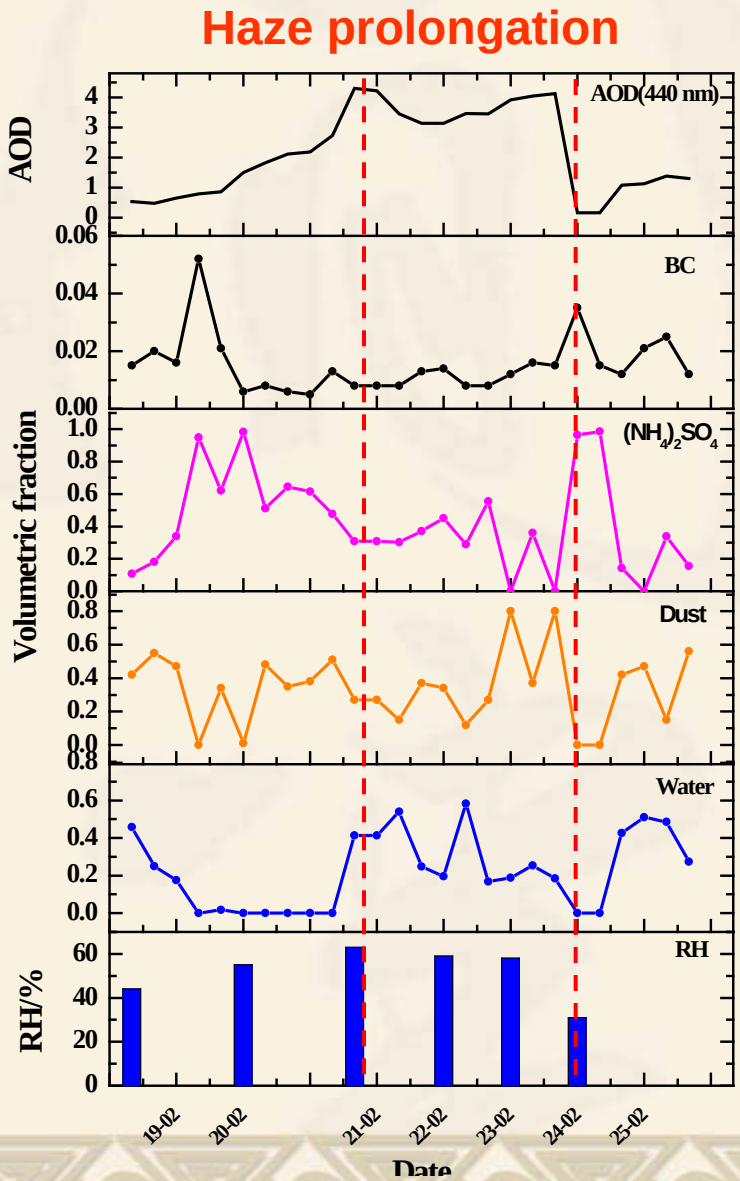
Variation of aerosol components



- **Aerosol water content approaches 0 during the haze formation.**
- **Volume fraction of BC and dust increase.**

This haze event is formed by accumulation of small particles (containing BC) and partially larger particles, instead of hygroscopic growth!

Variation of aerosol components during haze event



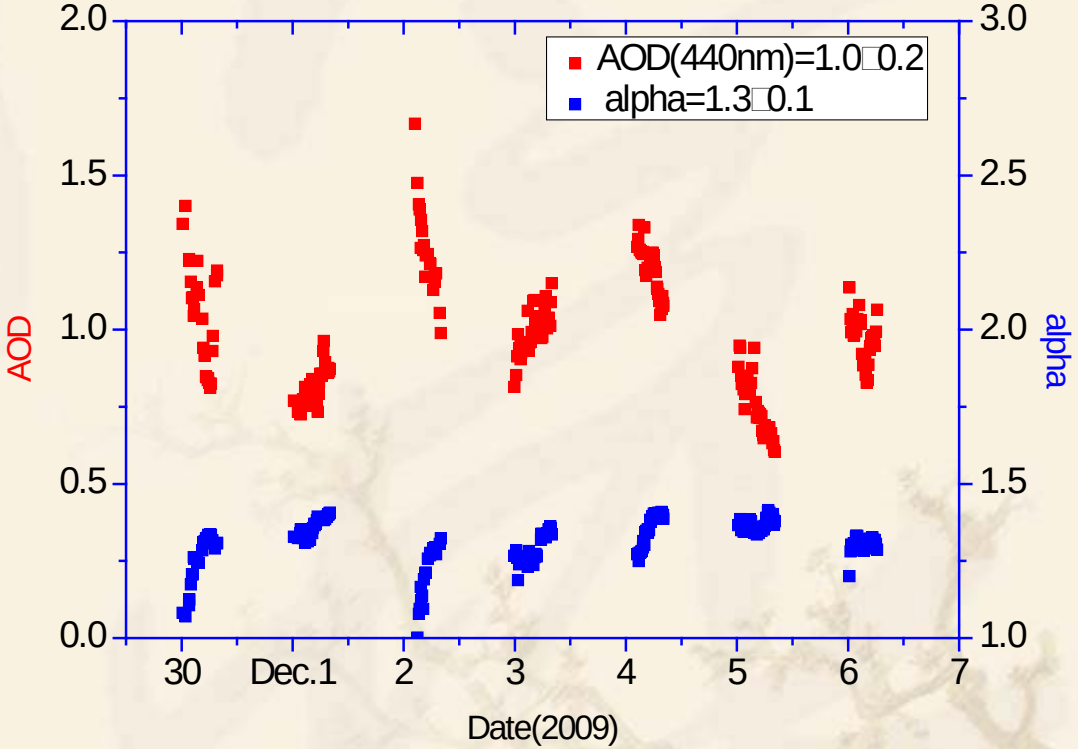
- Heavy haze lasted for 3 days :
  - **AOD(440nm) stayed for higher than 3 which brings important air quality prob.**
  - **Aerosol water content increase and become higher (hygroscopic progress).**

Haze properties at Zhongshan (South China)

30 Nov. - 6 Dec. 2009

Zhongshan site

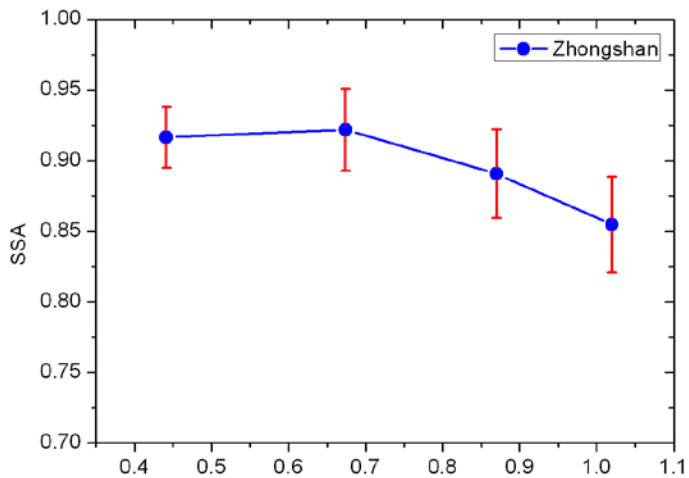
AOD(440nm) = 1.0 ± 0.2

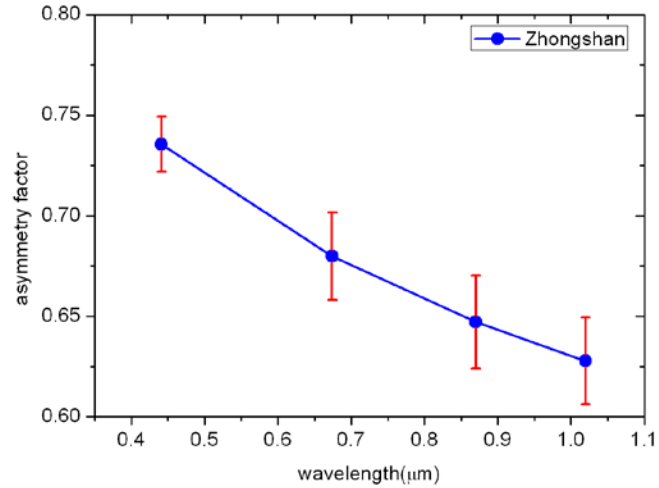


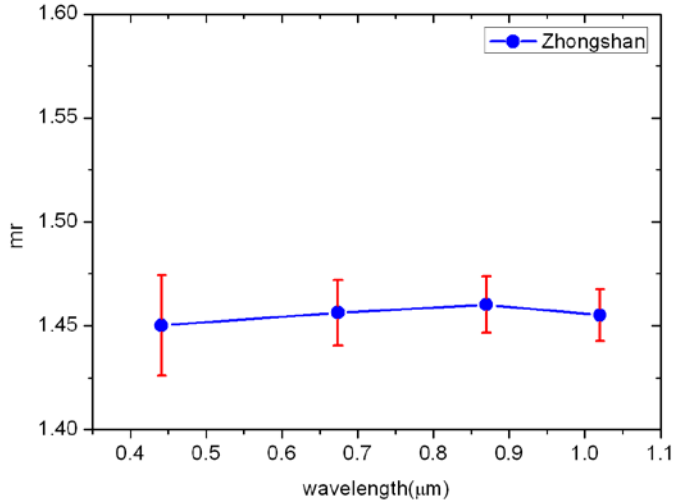
Rather stable aerosol conditions.

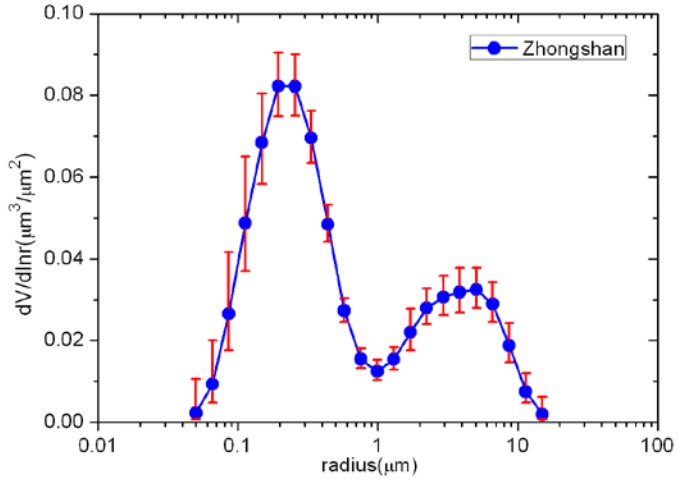
Zhongshan (near Guangzhou)

Typical aerosol properties at Zhongshan site (7 days average)

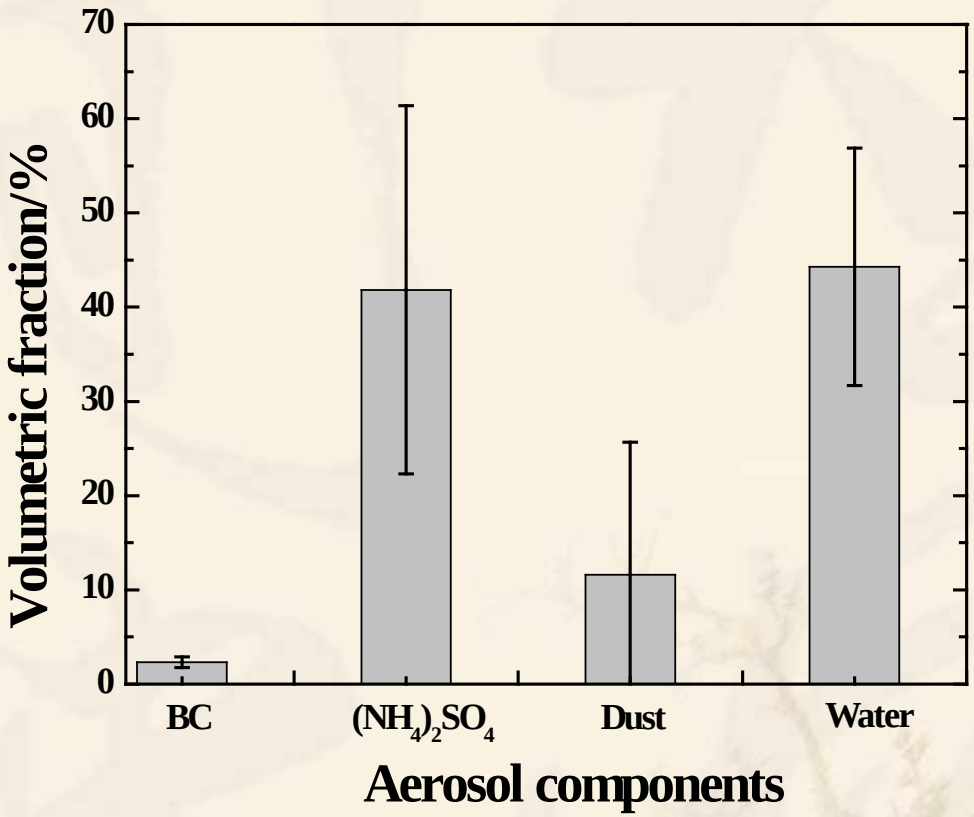








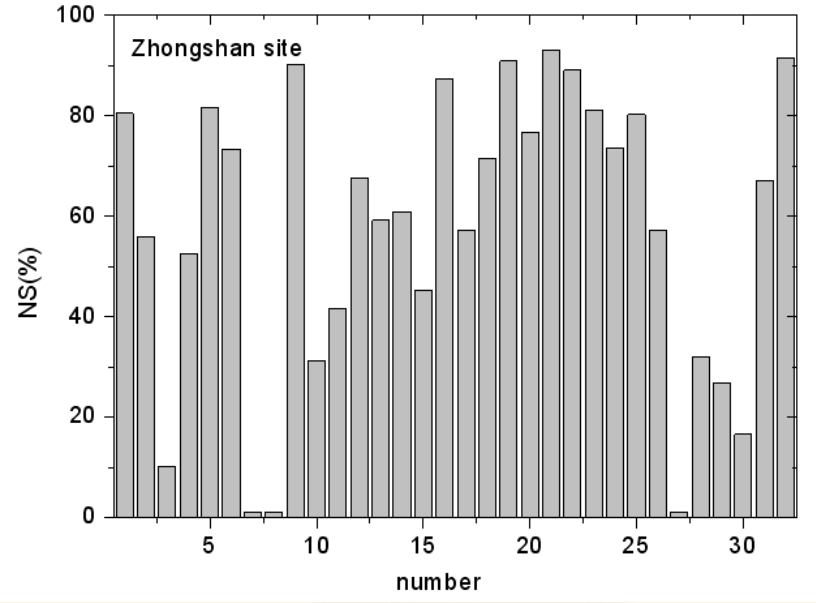
Zhongshan typical aerosol components



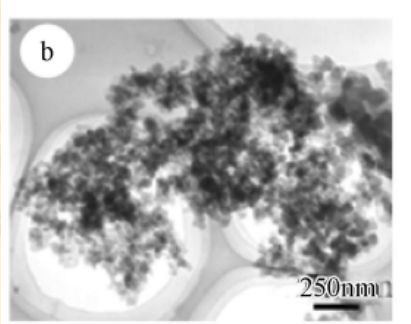
- **Fine particle components of BC and ammonium sulfate are dominate during the hazy days at Zhongshan.**

Averaged Zhongshan (South China) haze properties:

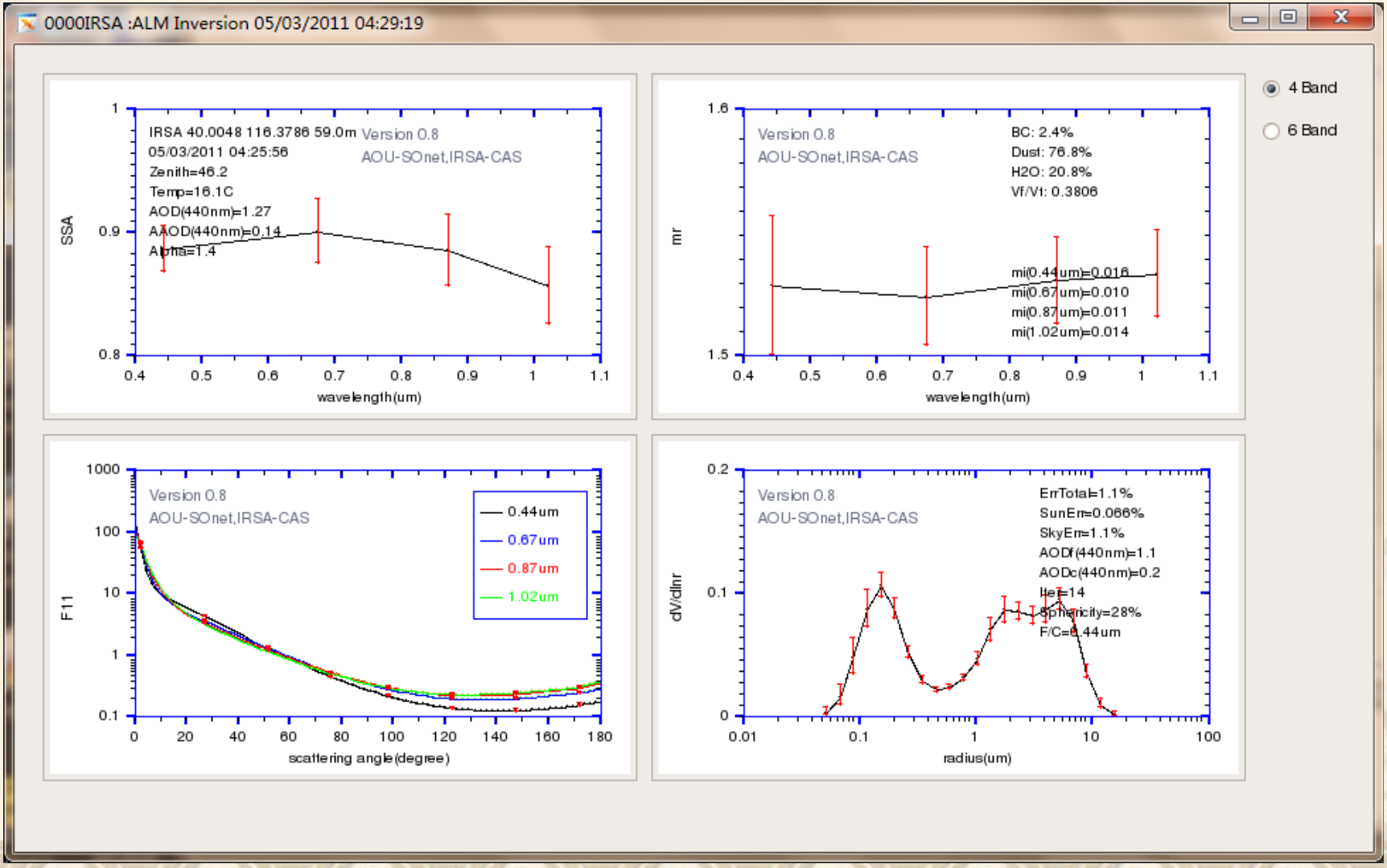
SSA (440nm)	mr (440nm)	Asy (440nm)	f/c separation
0.92±0.02	1.45±0.04	0.74±0.01	1.0um±0.3
BC	Mineral dust	$(NH_4)_2SO4$	Water
2%	12%	42%	44%



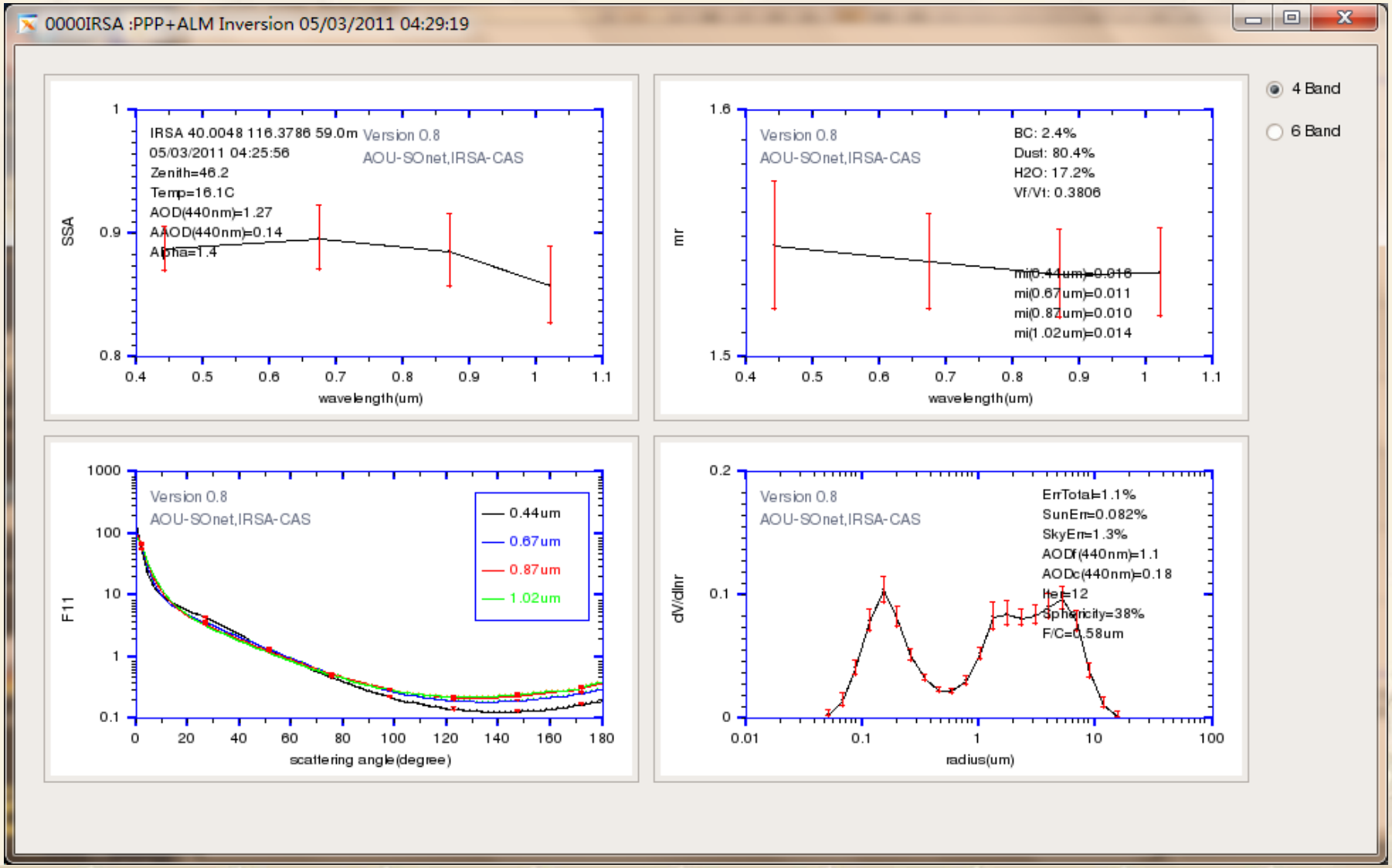
High averaged non-spherical particle's ratio (NS ~ 60%) further suggested aggregated or surface non-smooth particles:



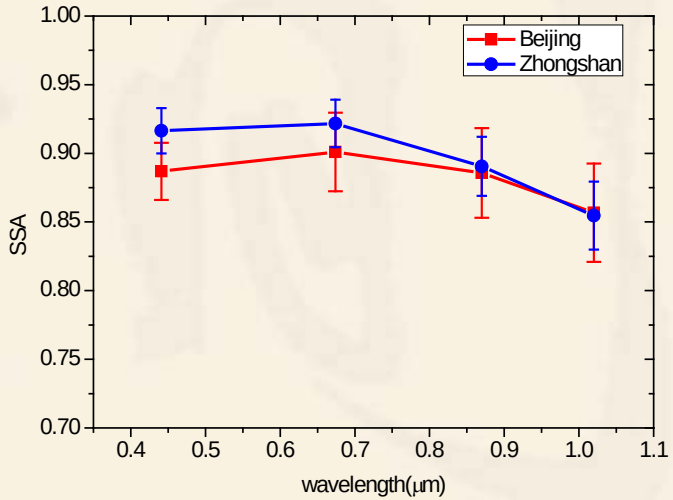
Beijing case (moderate haze) used to compare with Zhongshan average --- ALM (05/03/2011) 4:29

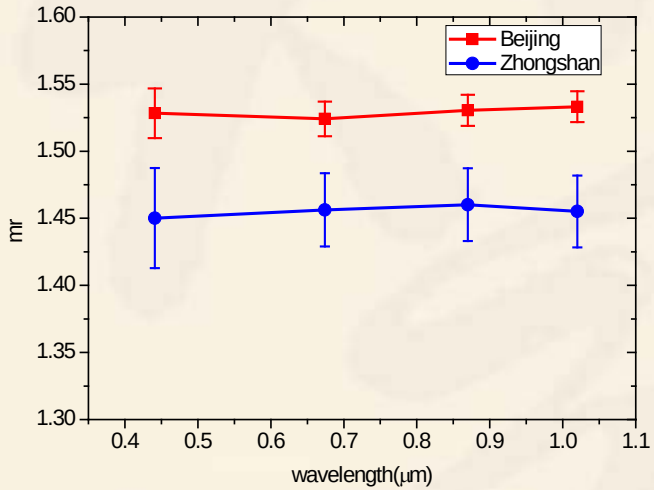


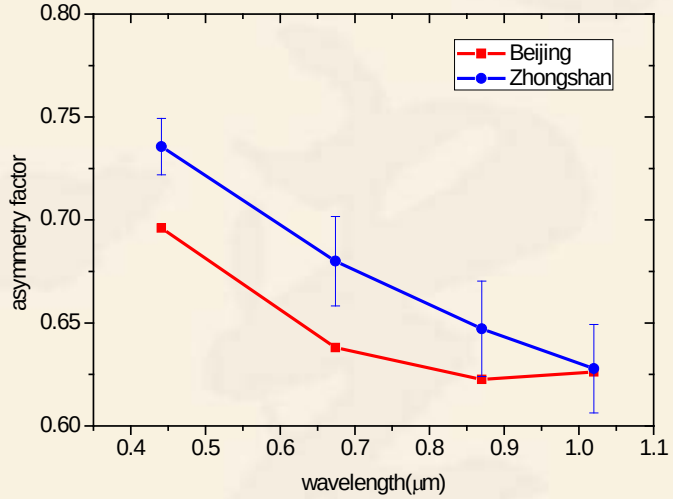
Beijing case verification by taking into account polarization measurements:

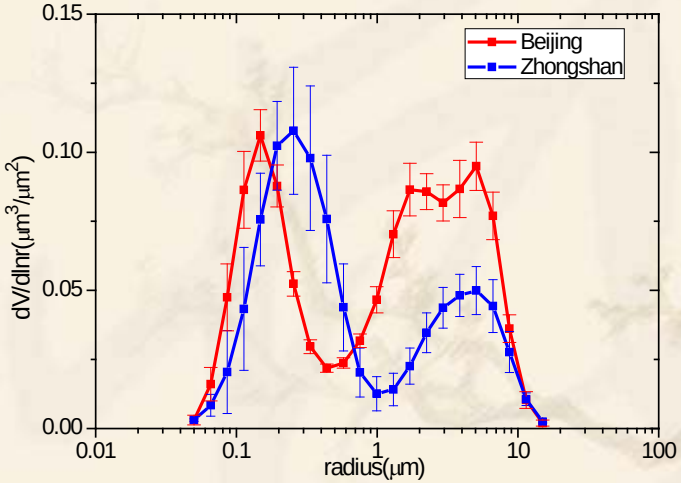


Aerosol properties: Zhongshan vs. Beijing

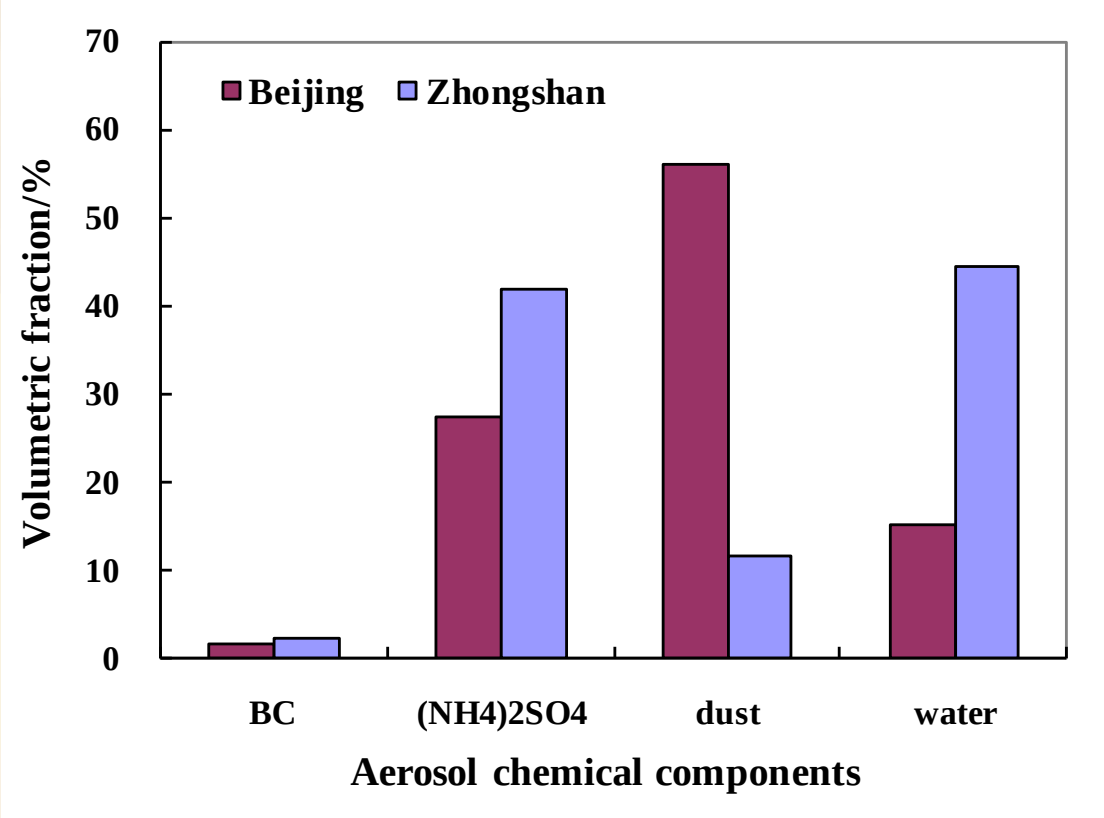






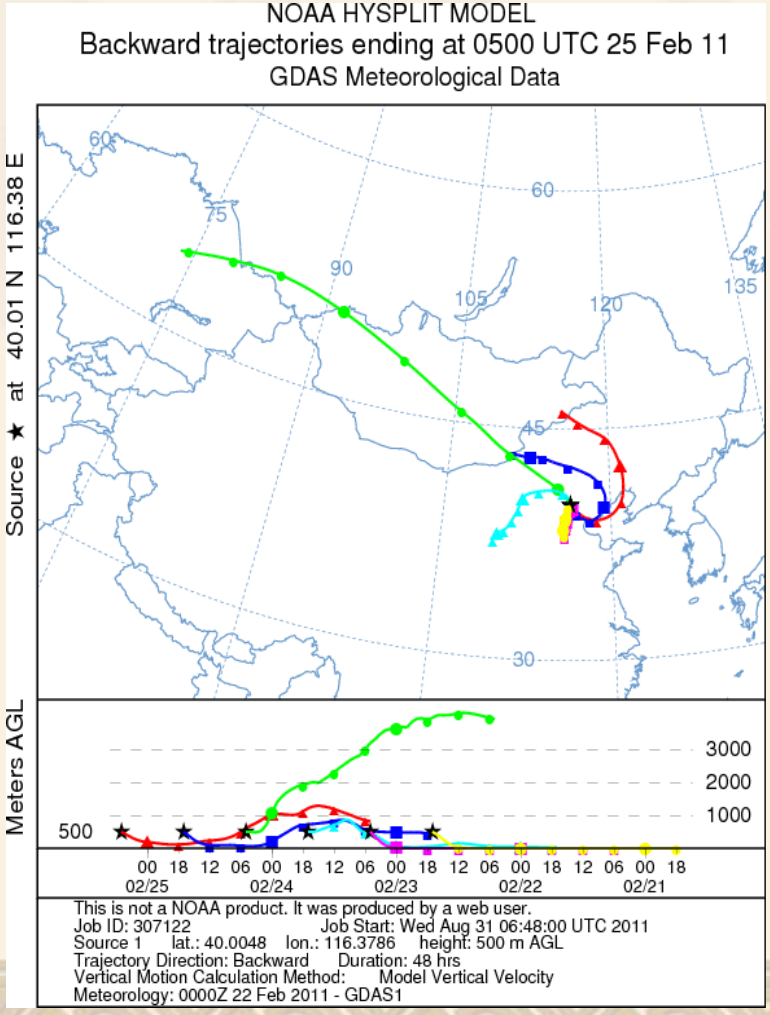


Particle components: Zhongshan vs. Beijing

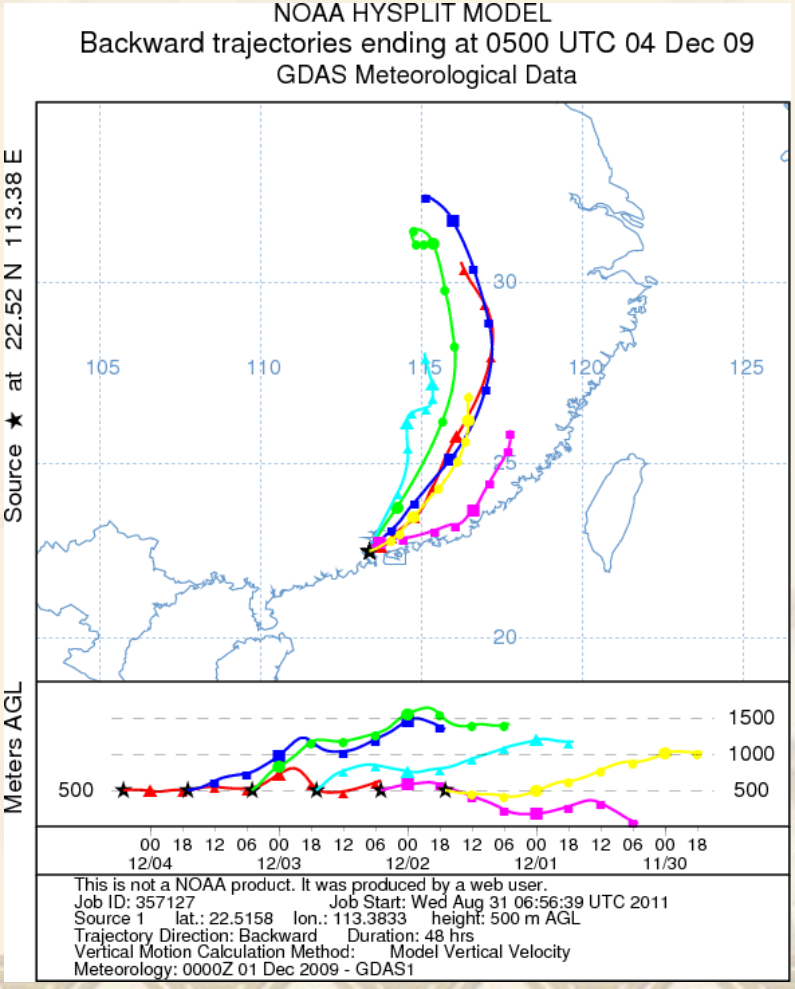


Source and transport analysis by backward trajectories:

Beijing: from local and north arid region



Zhongshan: from industrial mainland



Conclusion on haze properties in north (BJ) and south (ZS) china

(1) North China haze has more mineral dust components (e.g. 60% vs. 10%);

(2) South China haze particle has more water (e.g. 40% vs 20%)

(3) Systematic comparison and analyses are on going.

Thanks !