

Overview of the AMF-China Campaign and Research



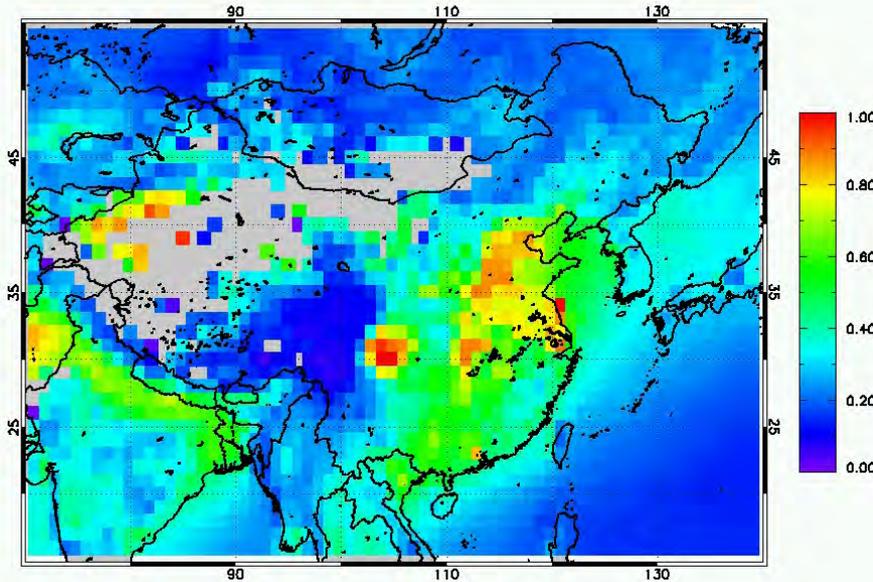
Zhanqing Li

Dept of Atmospheric & Oceanic Science

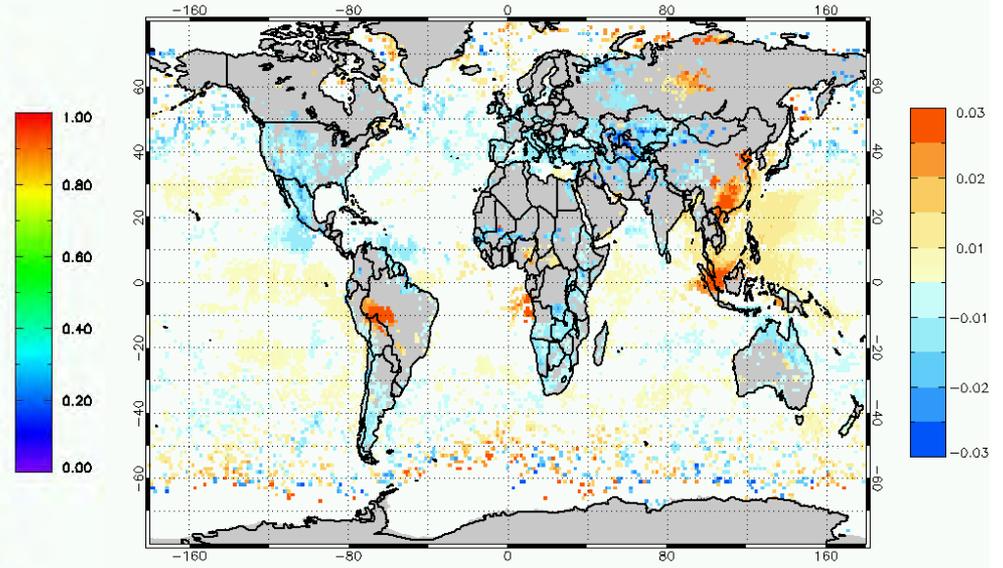
University of Maryland

Contributors and collaborator: T.-S. Tsay, H. Chen, J. Huang, W. Zhang, R. Hansell, Z. Chaudhry, C. Flynn, M. Cadeddu, C. Chiu, M. Miller, D. Turner, Y. Zheng, B. Holben, K. Lee, M. Cribb, W.-C. Wang, Kummerow, S. Menon

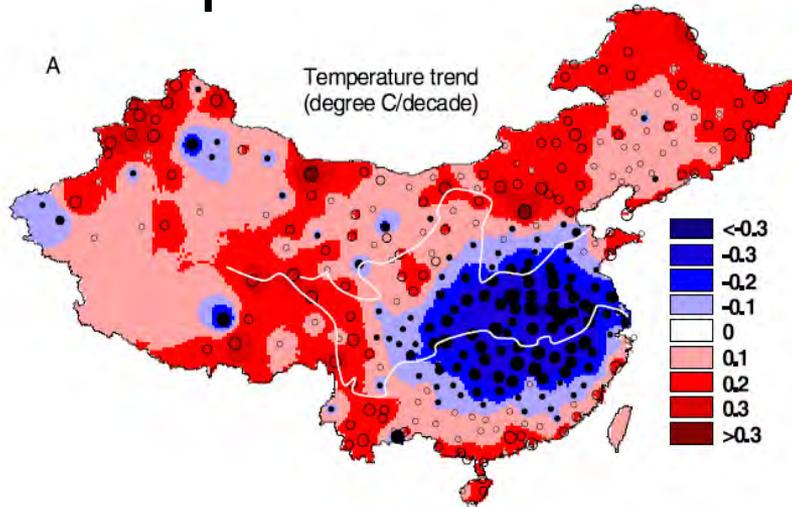
Mean MODIS AOT



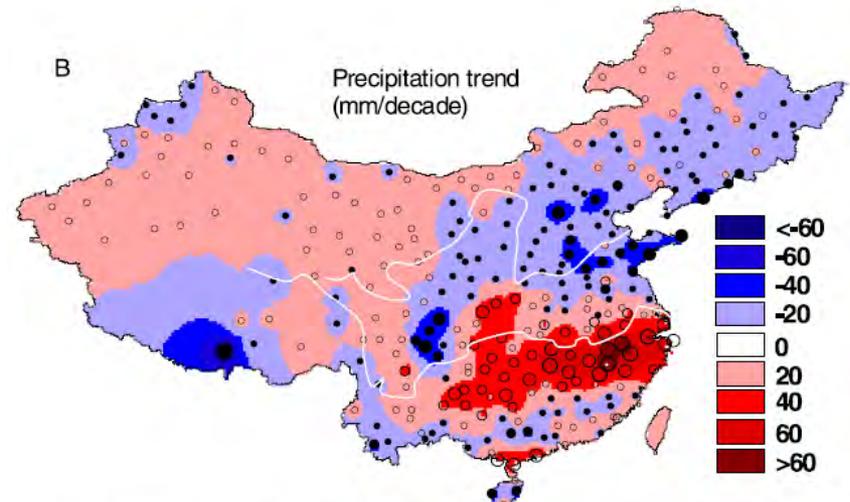
MODIS AOT Trend



Temperature Trend

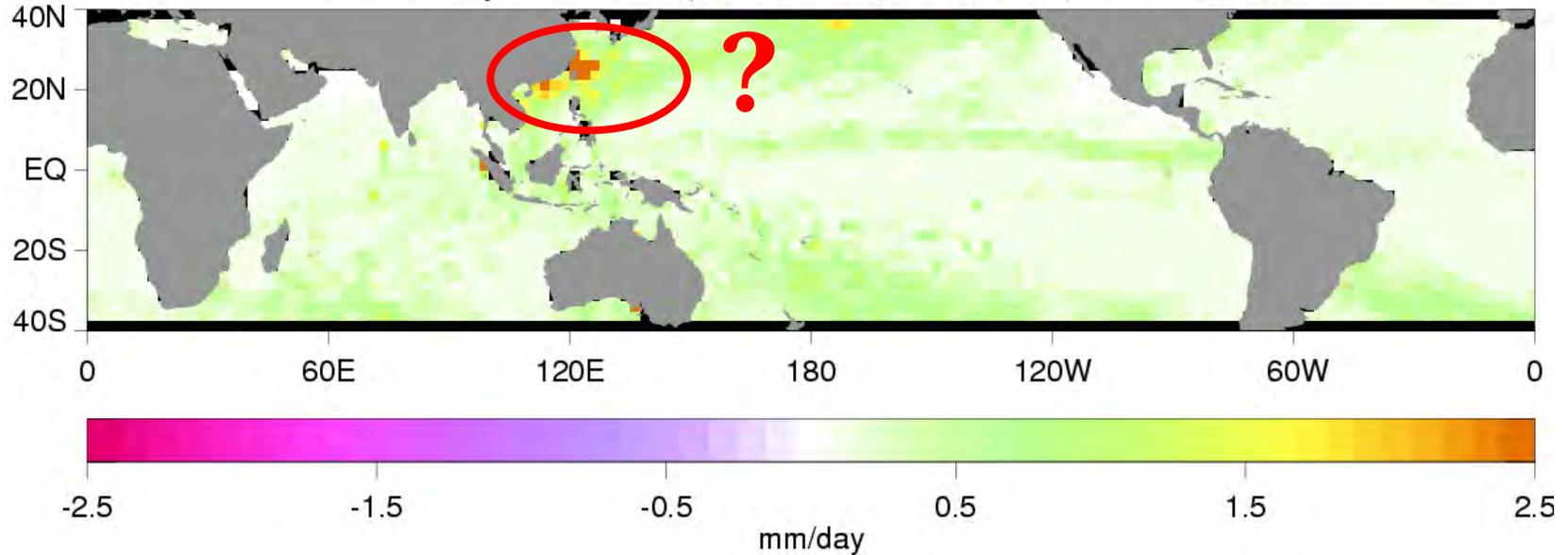


Rainfall Trend



Aerosol Impacts on Precip. from TRMM

TMI Only Rainfall ($RR_{TMI} > 0, RR_{PR} = 0$) DJF 99/00



TRMM Microwave Imager

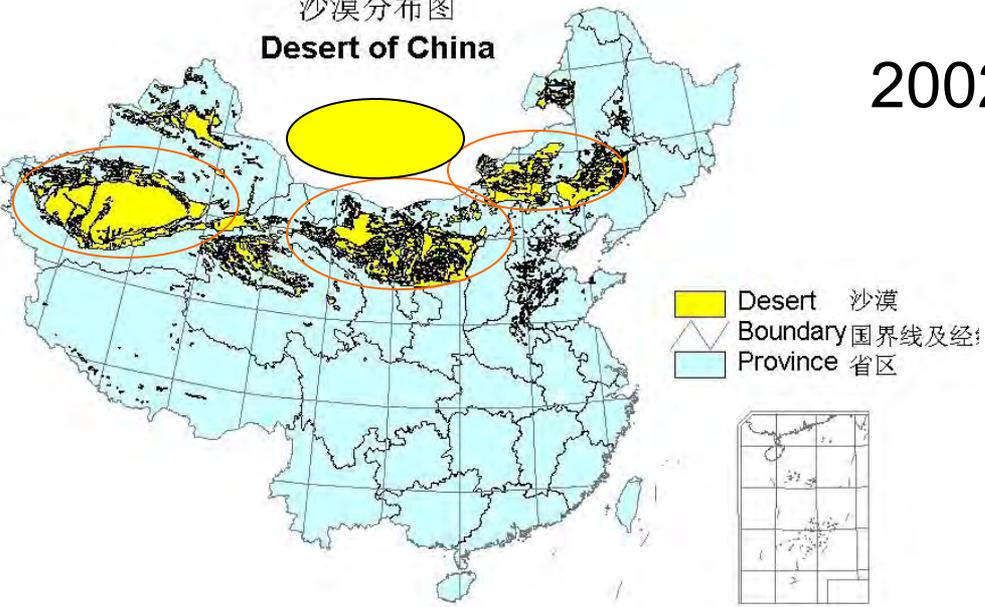
- Emission-based
- Integral measurement
- Low spatial resolution
- Affected by both cloud water and rainfall

Precipitation Radar

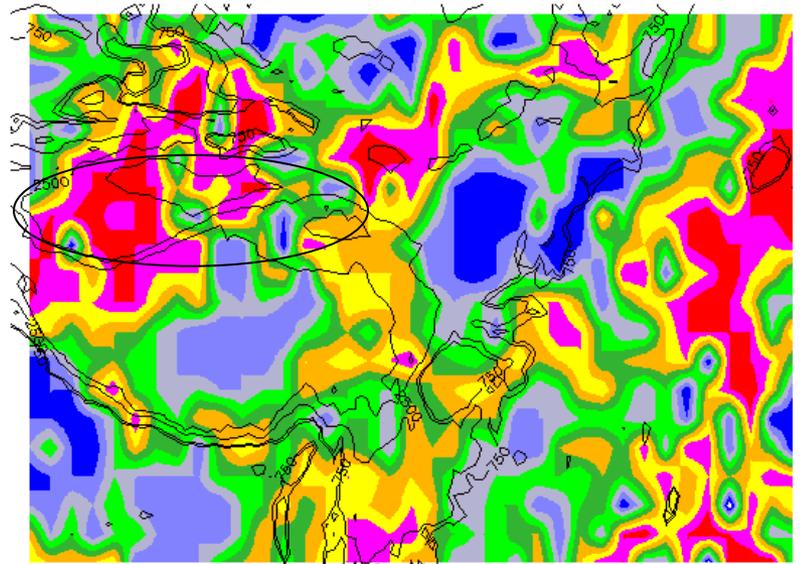
- Backscatter-based
- Vertically-resolved
- 4 km spatial resolution
- Dominated by rainfall

L'Ecuyer, Berg, C. Kummerow

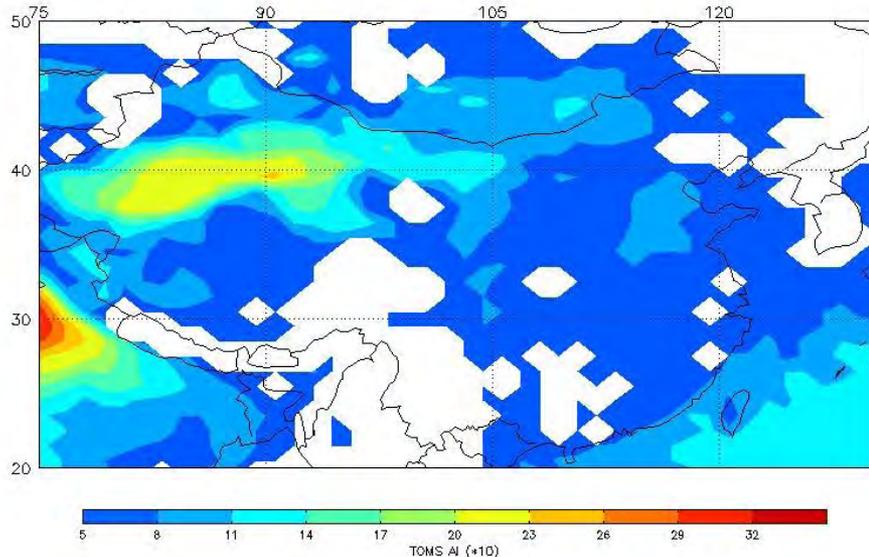
沙漠分布图
Desert of China



2002



Monthly/Seasonal mean TOMS AI
Jul-Aug 2002



Features to notice

- Correspondence between areas with large AI value and desert distribution
- In Northwestern China and southern Mongolia there is a band of area with large ice particle sizes
- There's an established land-sea contrast in terms of DER size

Science Questions

- ***What are the properties and spatial and temporal variations of aerosols in China?***
- ***How do the heavy aerosols affect cloud, precipitation, radiation and atmospheric circulation?***
- ***To what extent do changes in aerosol emissions in China contribute to the observed changes?***
- ***What are the impacts of aerosols emitted in China on the East Asian monsoon system?***

AMF Primary and Supplementary Sites

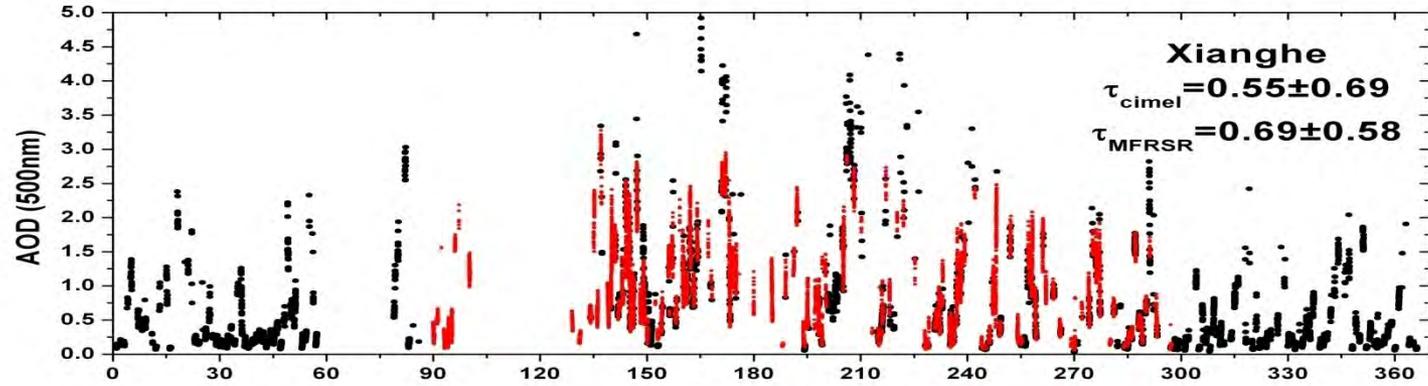


Anchored by the AMF in Shouxian, additional instrumented sites to the east and north provided a comprehensive atmospheric data set for studying aerosol effects in the region.

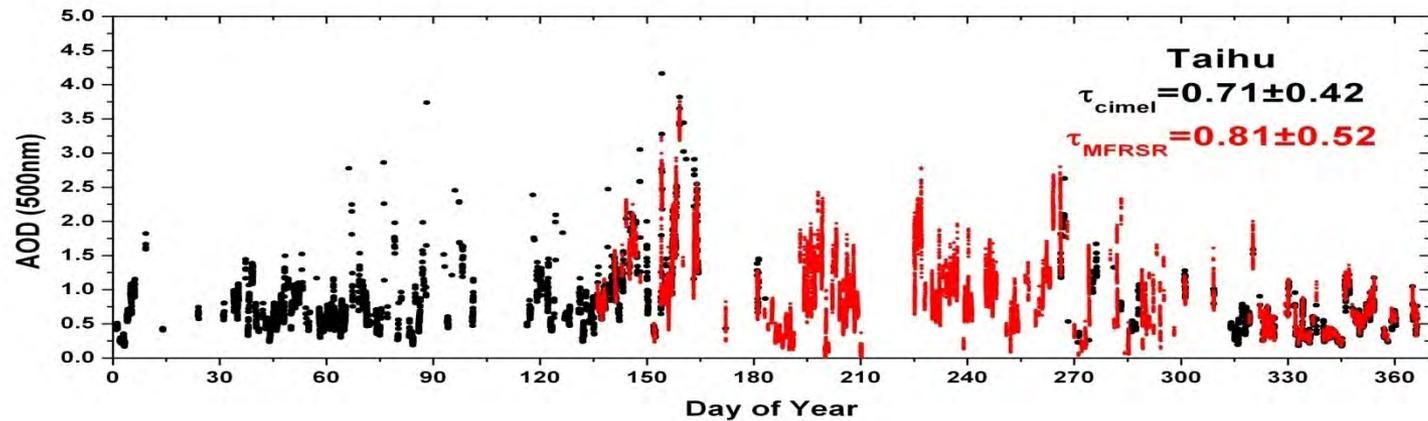
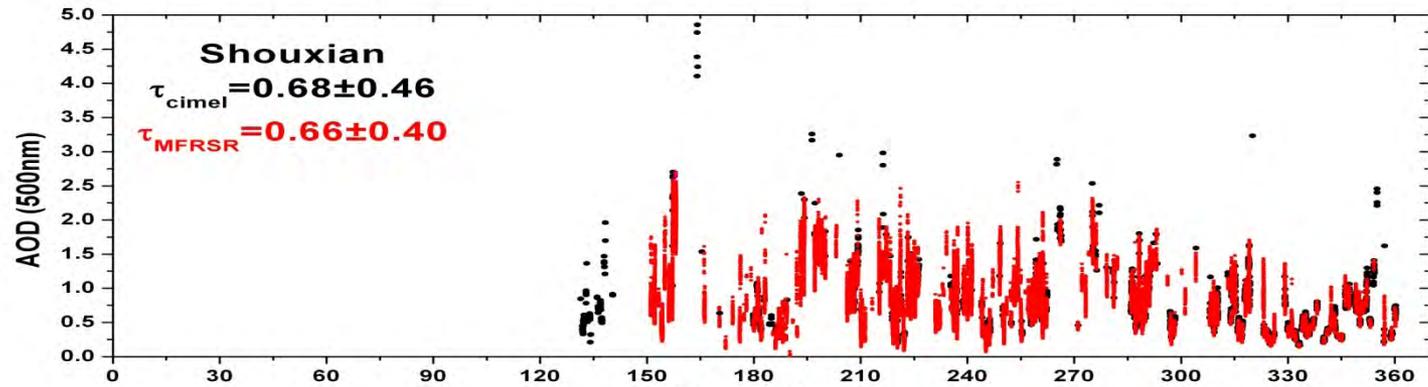
Major Milestones

- **Apr 2, AMF/AAF trailers cleared for deployment**
- **May 6, First light for most instruments**
- **June 4, WACR and NFOV, arrived in Shouxian**
- **June 24, AAF moved from Zhangye to Xianghe**
- **Nov 10, AAF on the way back to US**
- **Dec. 25, shutdown in Taihu**
- **Dec. 29, shutdown in Shouxian**
- **Mar. 18, AMF DATA RELEASED!**

AOD records during 2008



Black: Cimel
Red: MFRSR

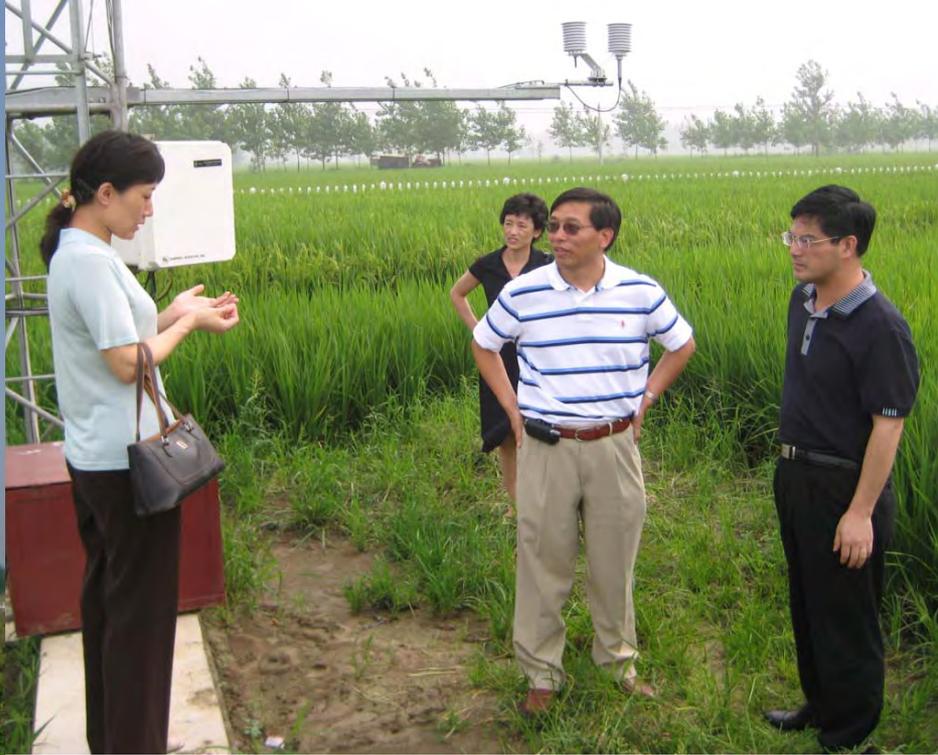


Shouxian Climate Observatory

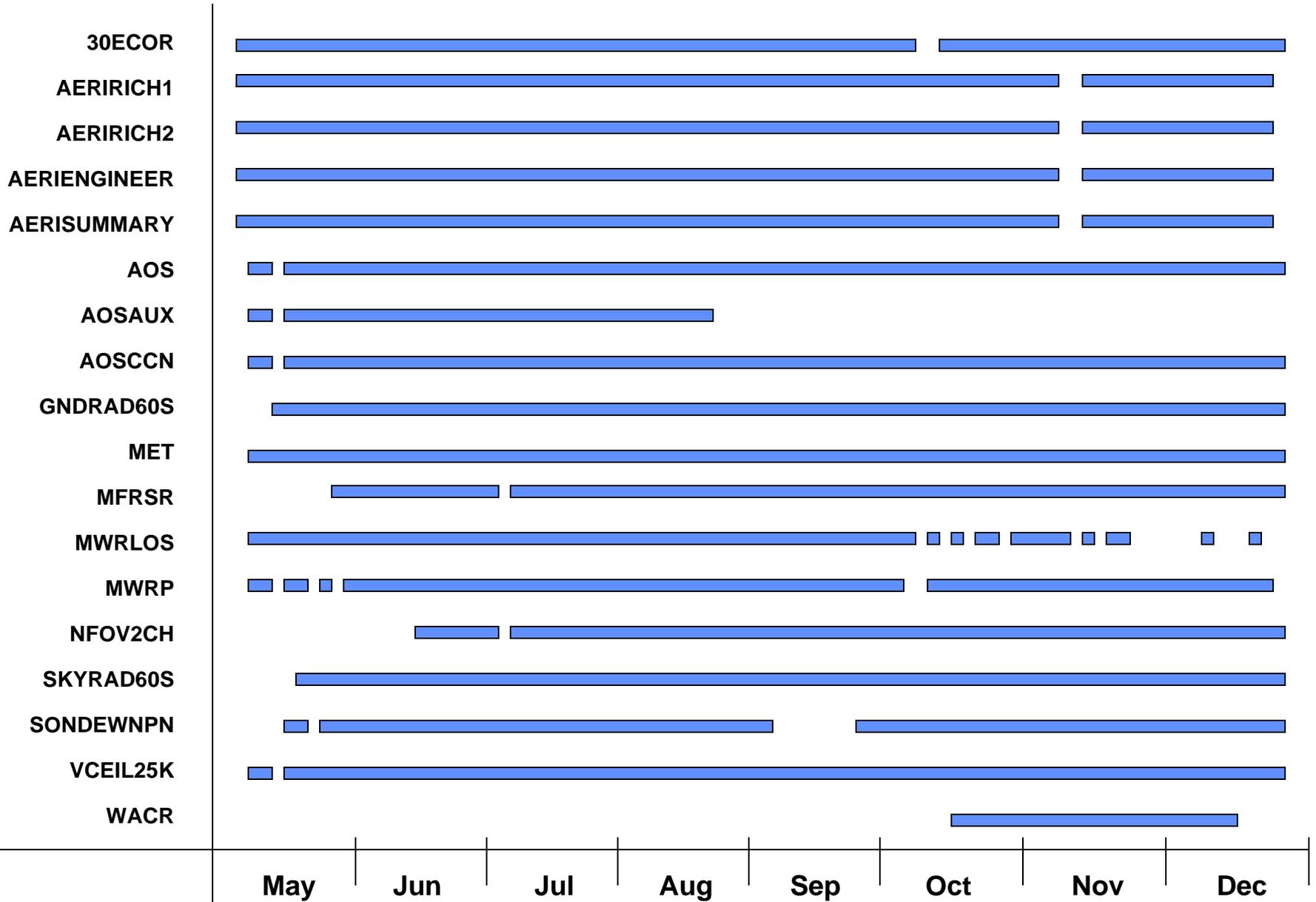


ARM Mobile Facility Deployment in Shouxian





HFE Summary of Completeness: May 1, 2008 – Dec. 31, 2008

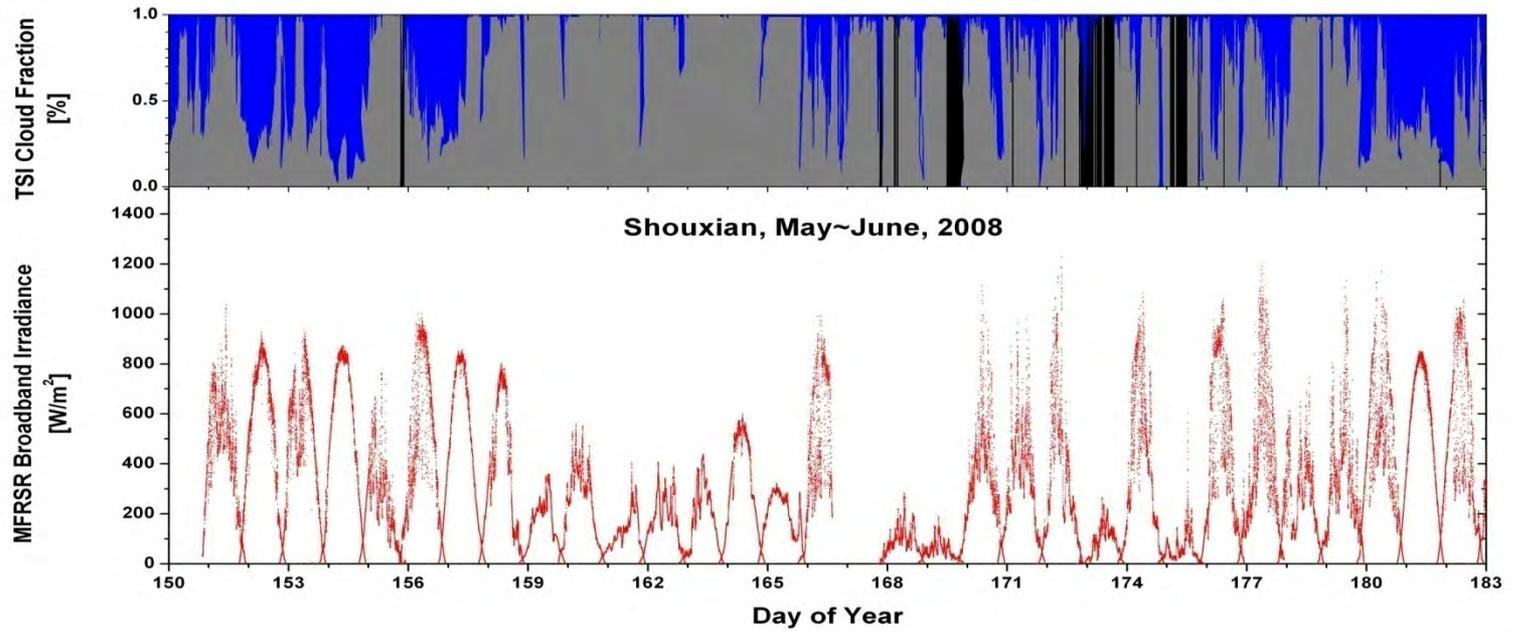


HFE Summary of Completeness: May 1, 2008 – Dec. 31, 2008

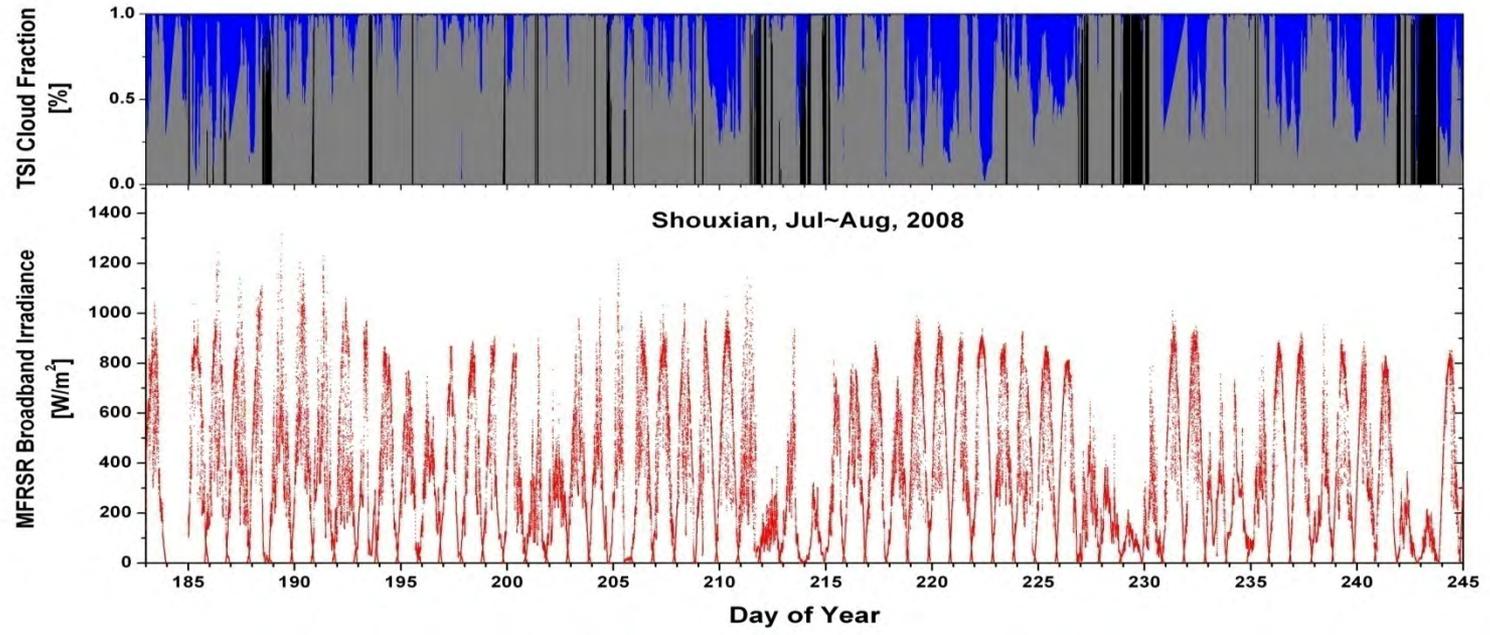
** Percentages represent percent of month for which there are daily files.*

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
30ECOR	84%	100%	100%	100%	100%	94%	100%	90%	96%
AERIRICH1	84%	100%	100%	100%	100%	100%	90%	87%	95%
AERIRICH2	84%	100%	100%	100%	100%	100%	90%	87%	95%
AERIENGINEER	84%	100%	100%	100%	100%	100%	90%	87%	95%
AERISUMMARY	84%	100%	100%	100%	100%	100%	90%	87%	95%
AOS	74%	100%	100%	100%	100%	100%	100%	90%	96%
AOSAUX	74%	100%	100%	74%	0%	0%	0%	0%	44%
AOSCCN	74%	100%	100%	100%	100%	100%	100%	90%	96%
GNDRAD60S	70%	100%	100%	100%	100%	100%	100%	90%	95%
MET	77%	100%	100%	100%	100%	100%	100%	90%	96%
MFRSR	10%	100%	100%	100%	100%	100%	100%	90%	88%
MWRLOS	77%	100%	100%	100%	100%	58%	43%	6%	73%
MWRP	61%	100%	100%	100%	100%	94%	100%	87%	93%
NFOV2CH	0%	53%	97%	100%	100%	100%	100%	90%	80%
SKYRAD60S	52%	100%	100%	100%	100%	100%	100%	90%	93%
SONDEWNPN	55%	100%	100%	100%	43%	100%	100%	90%	86%
VCEIL25K	74%	100%	100%	100%	100%	100%	100%	90%	96%
WACR	0%	0%	0%	0%	0%	55%	100%	48%	25%
Average	62%	92%	94%	93%	86%	89%	89%	77%	

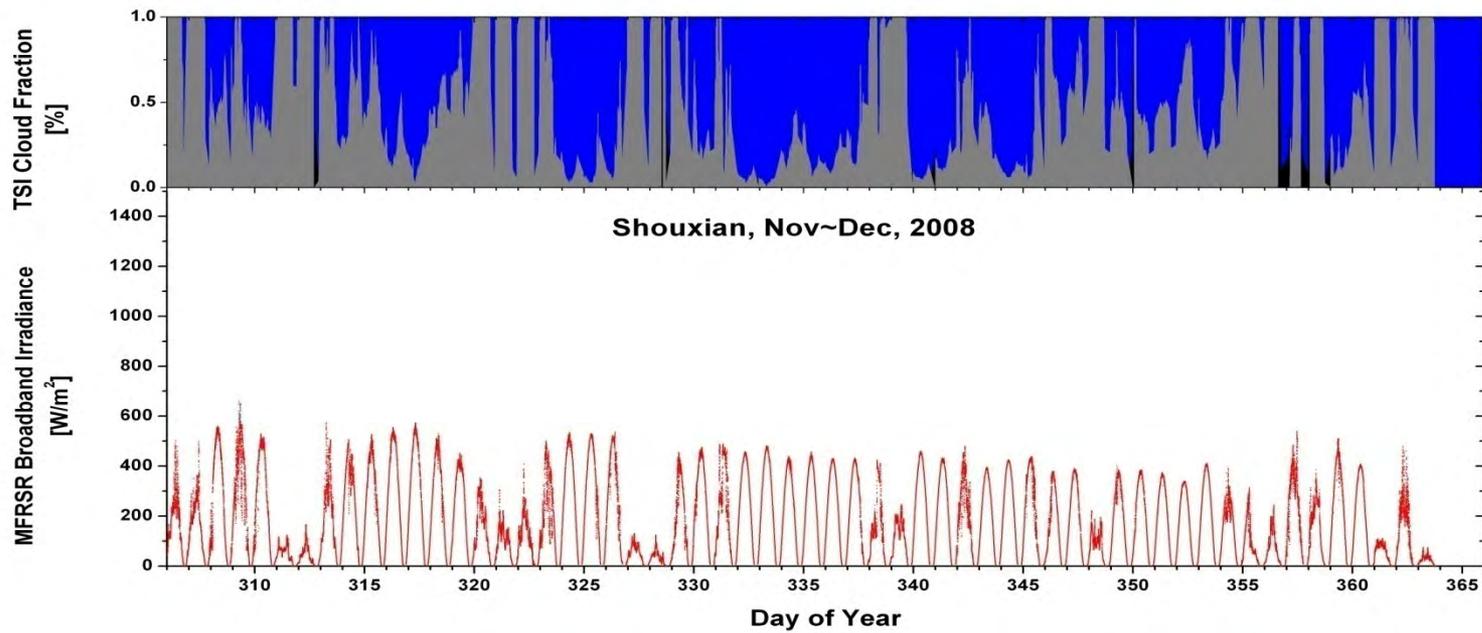
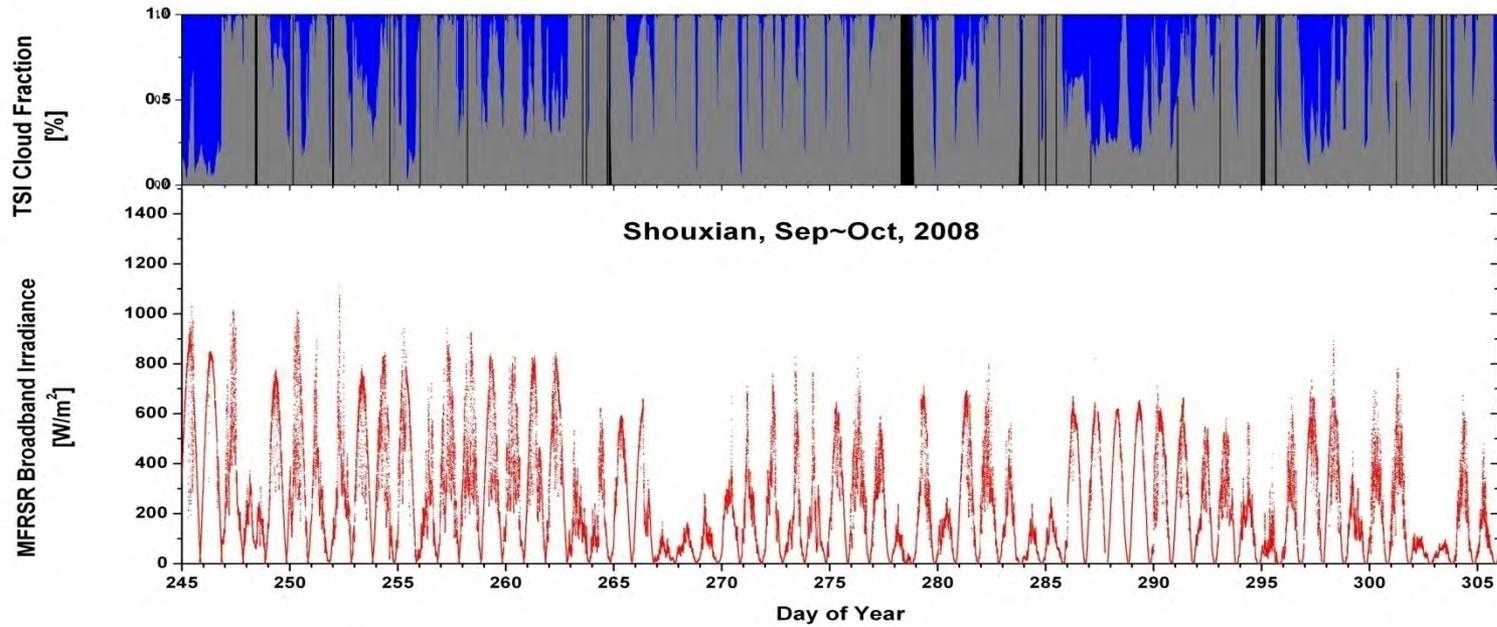
MFRSR broadband radiation & TSI cloud opaque (%)



Black: Precipitation
Gray: Cloud
Blue: clear sky
Red: MFRSR

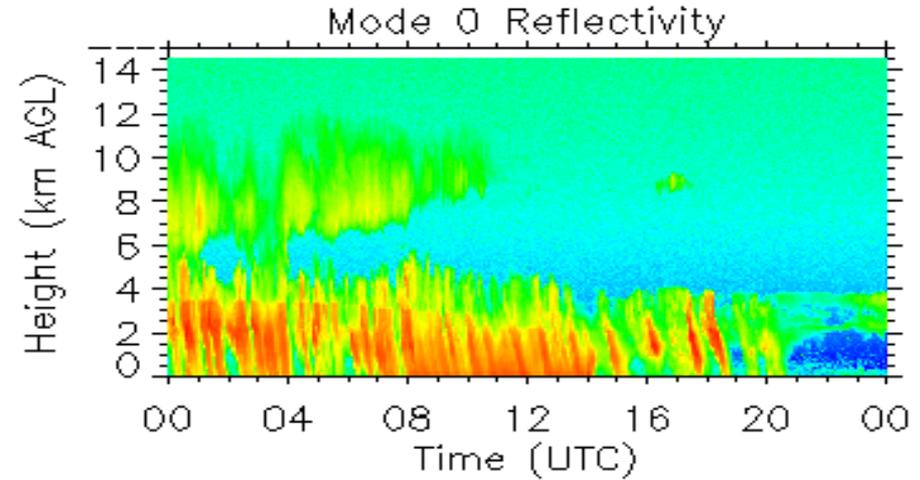


MFRSR broadband radiation & TSI cloud fraction (%)

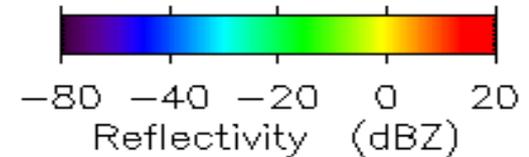
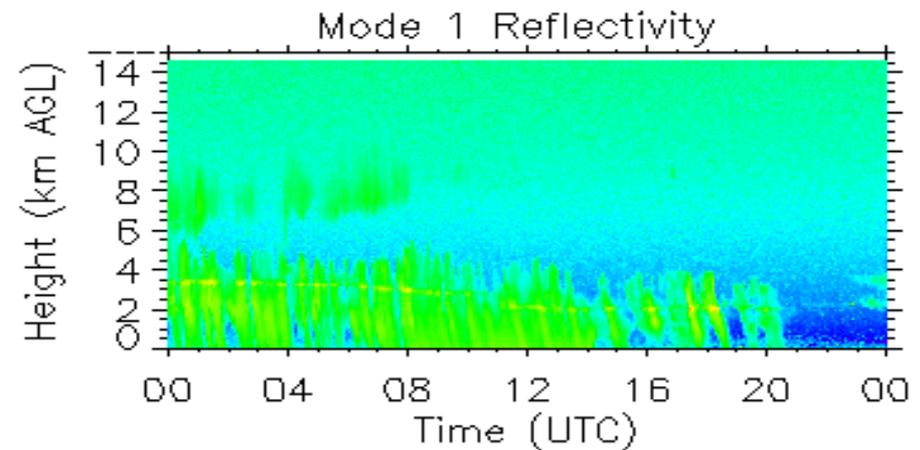
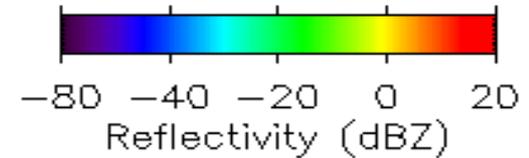




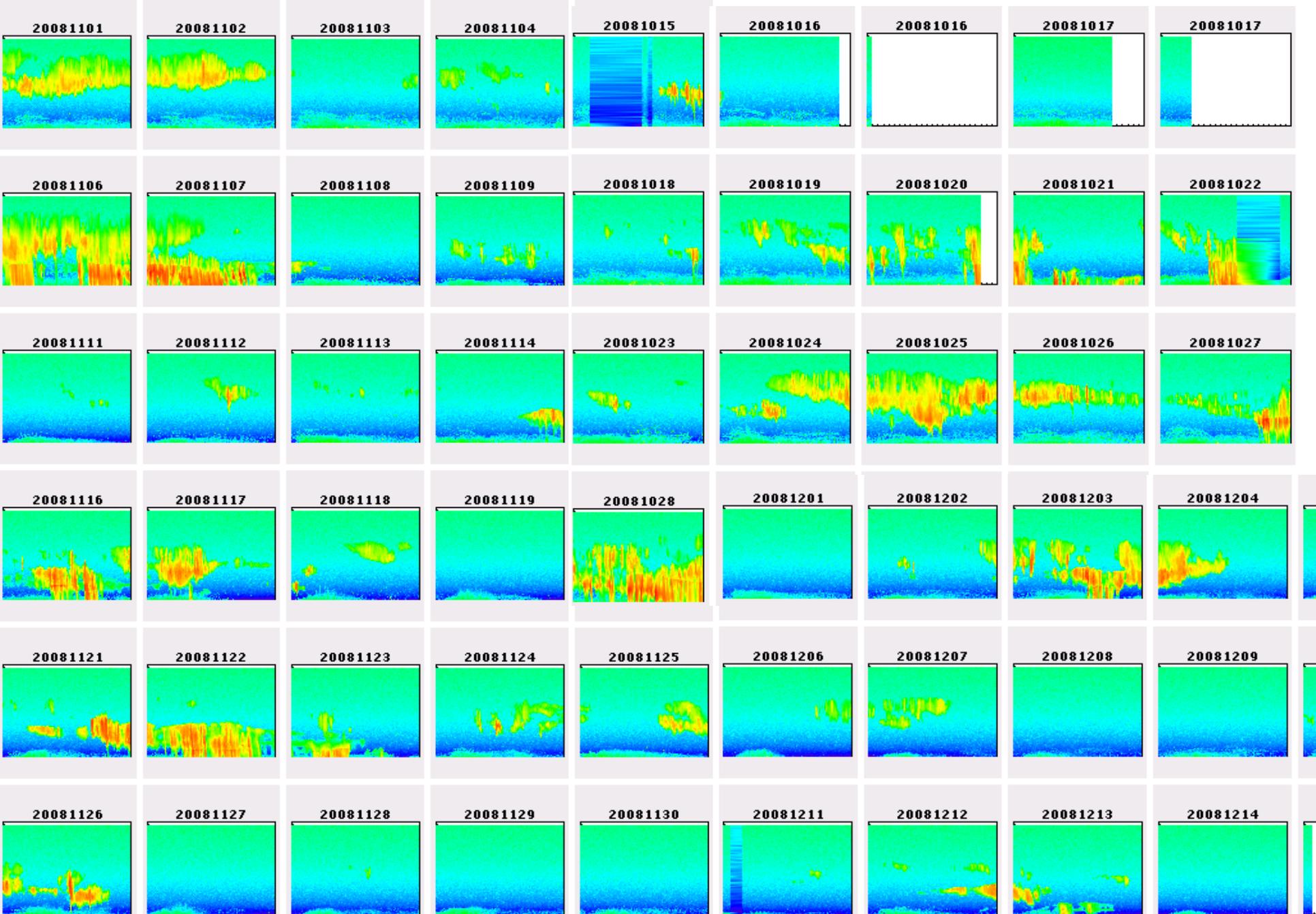
WACR Cloud Radar (Oct 15 – Dec 15)



2008-11-17

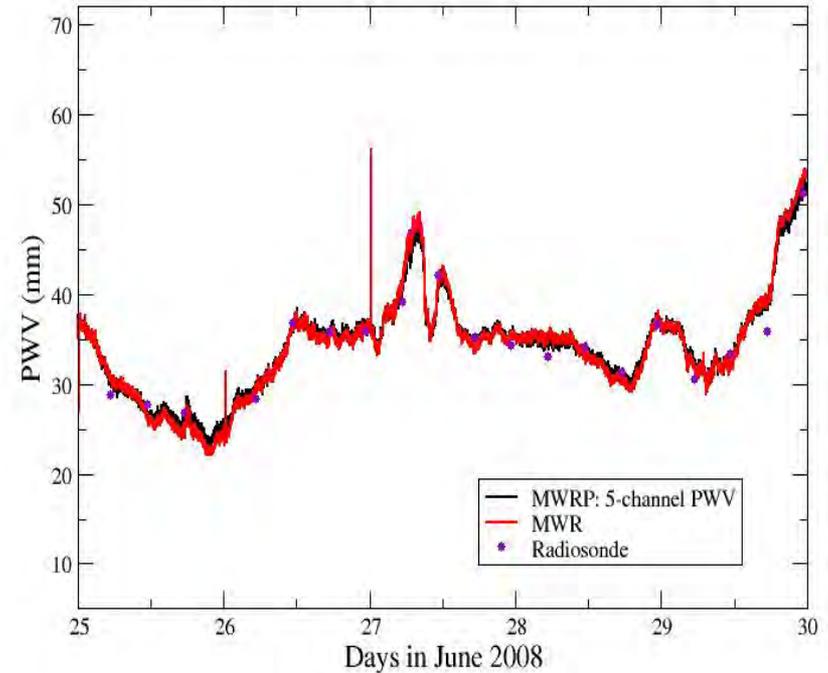


Instrument	Oct	Nov	Dec
WACR 95GHz	████████████████████		



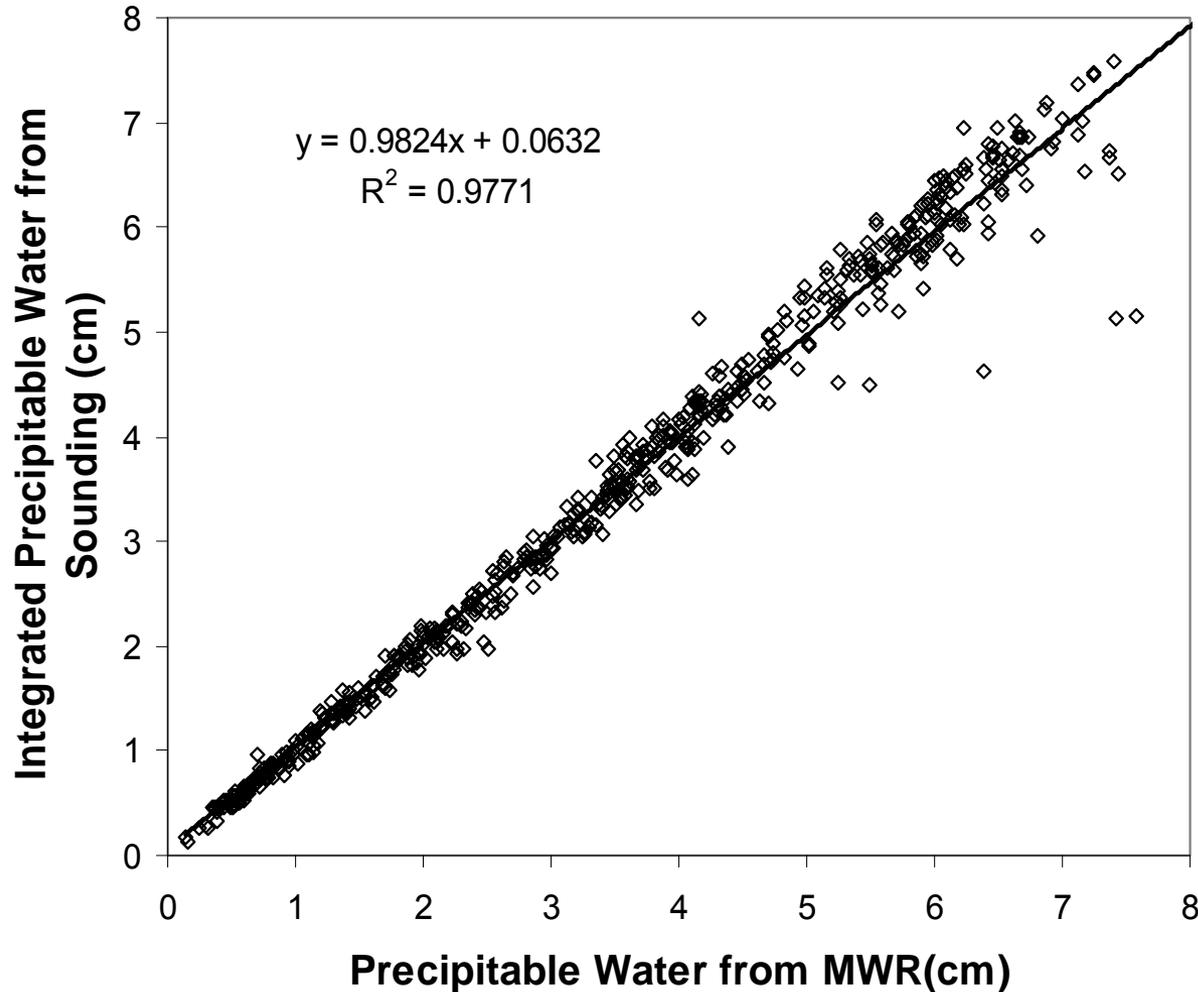
95 GHz Cloud Radar from Oct 15 to Dec 15, 2008

Microwave Radiometers in Shouxian



Instrument	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
MWF (23.8/31.4 GHz)		—————				•••••	•••••		
MWRHF (90/150 GHz)		—————		- - - -	- - - -	- - - -	- - - -	- - - -	
MWRP (22-30, 51-59GHz)	—————								

Precipitable Water from MWR and Sounding (Shouxian)

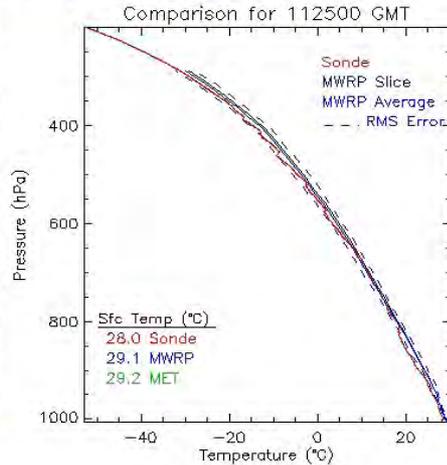
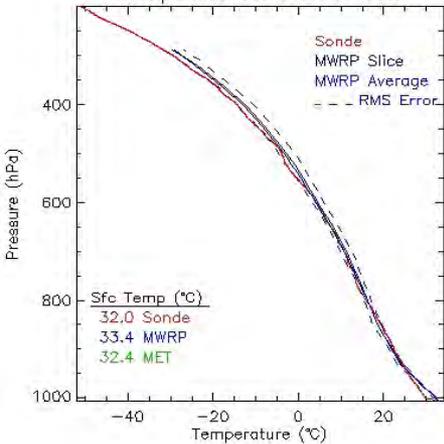


Comparison of Radiosonde and MWRP

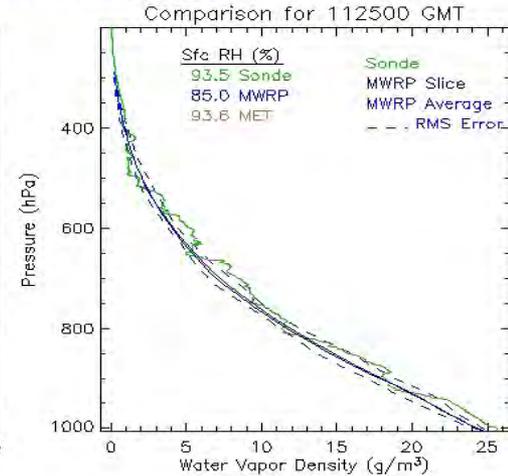
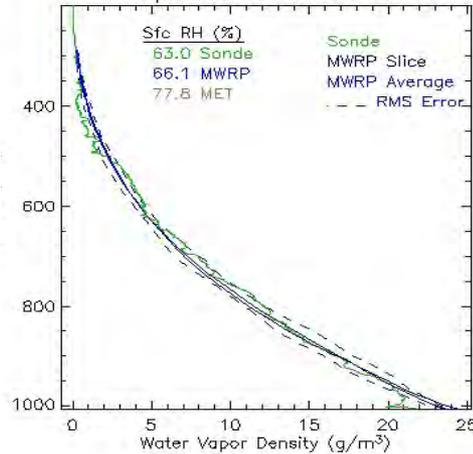
Temperature

Water Vapor Density

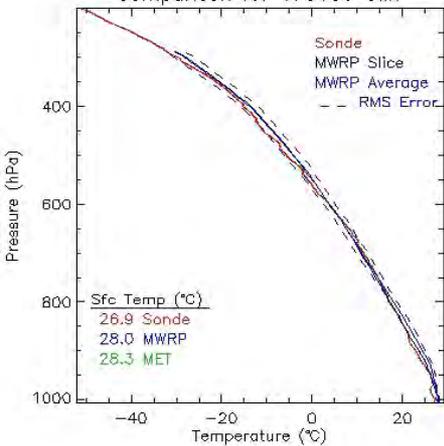
HFE MWRP vs. SONDE Temperature comparison for M1 on 20080804
Comparison for 052600 GMT



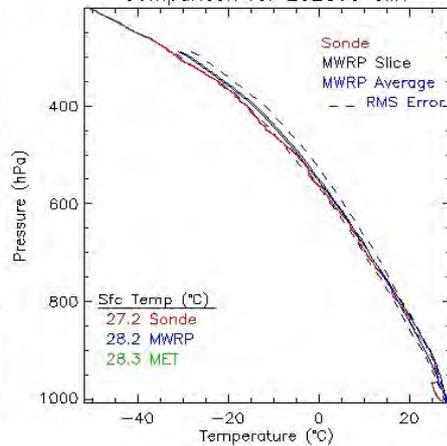
HFE MWRP vs. SONDE Water Vapor Density for M1 on 20080804
Comparison for 052600 GMT



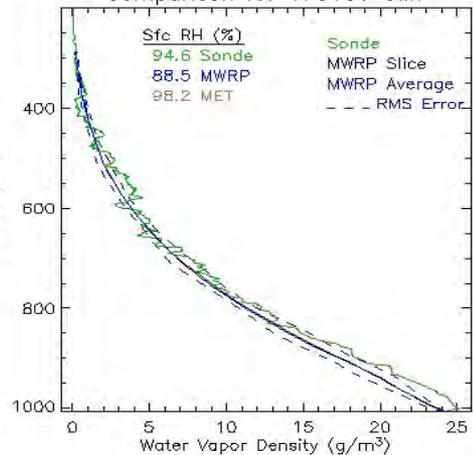
Comparison for 173100 GMT



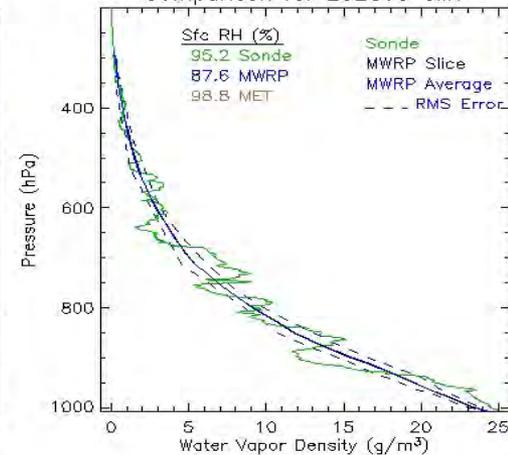
Comparison for 232800 GMT



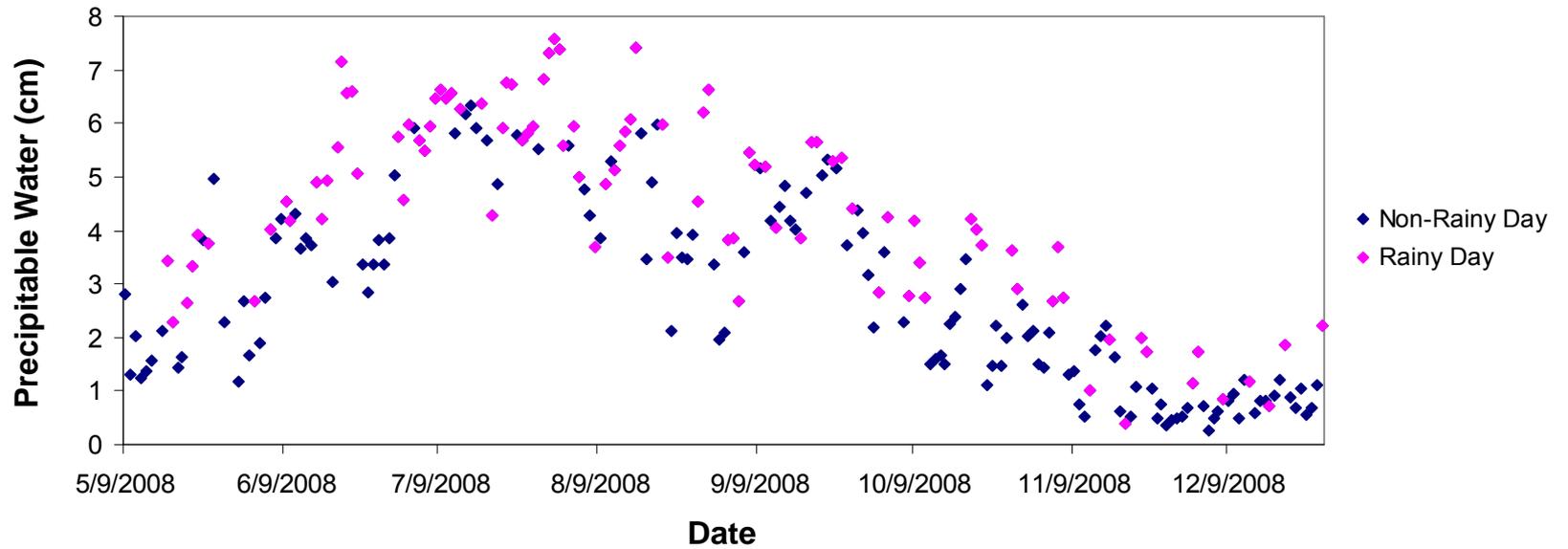
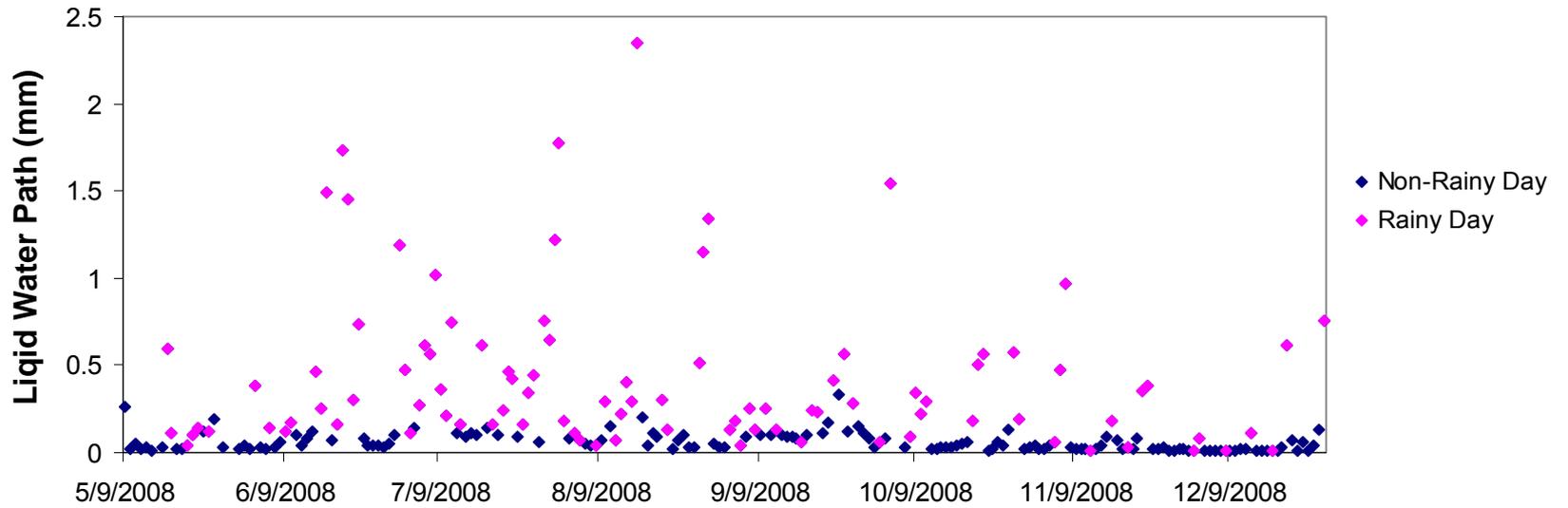
Comparison for 173100 GMT



Comparison for 232800 GMT

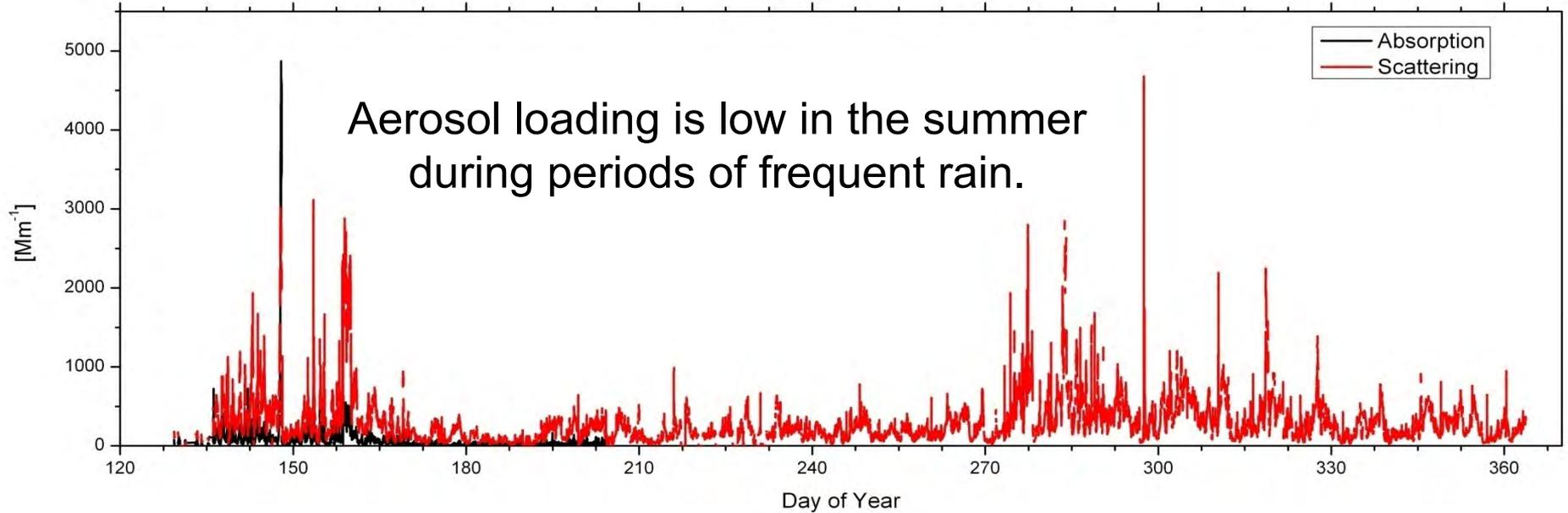


Shouxian

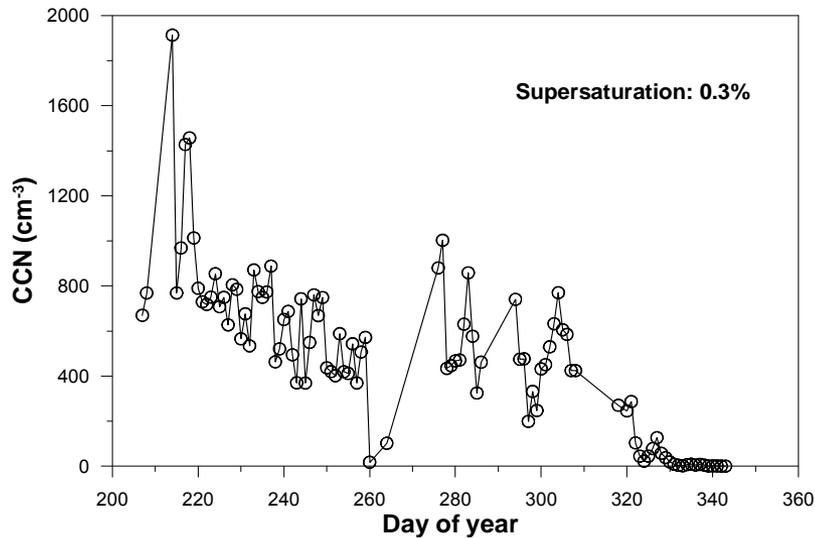


Aerosol Scattering & Absorption Coefficients for Shouxian

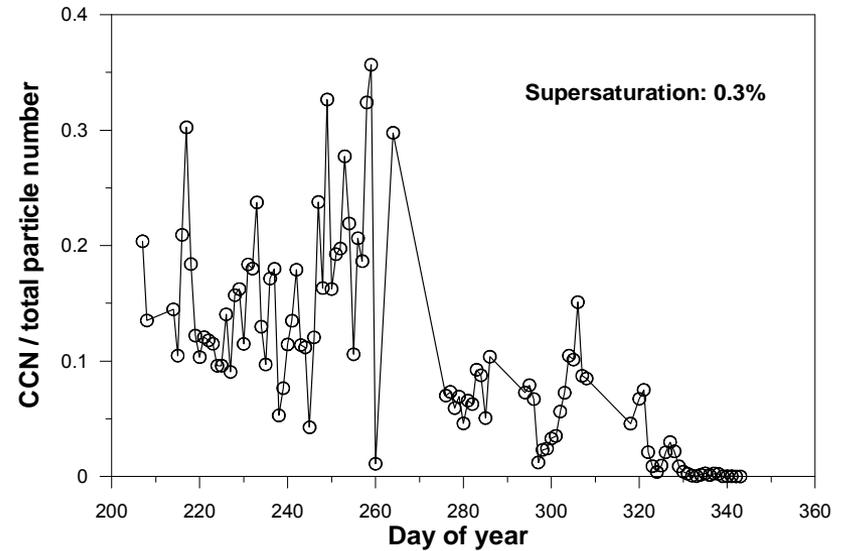
Sub 10 μm at 550 μm



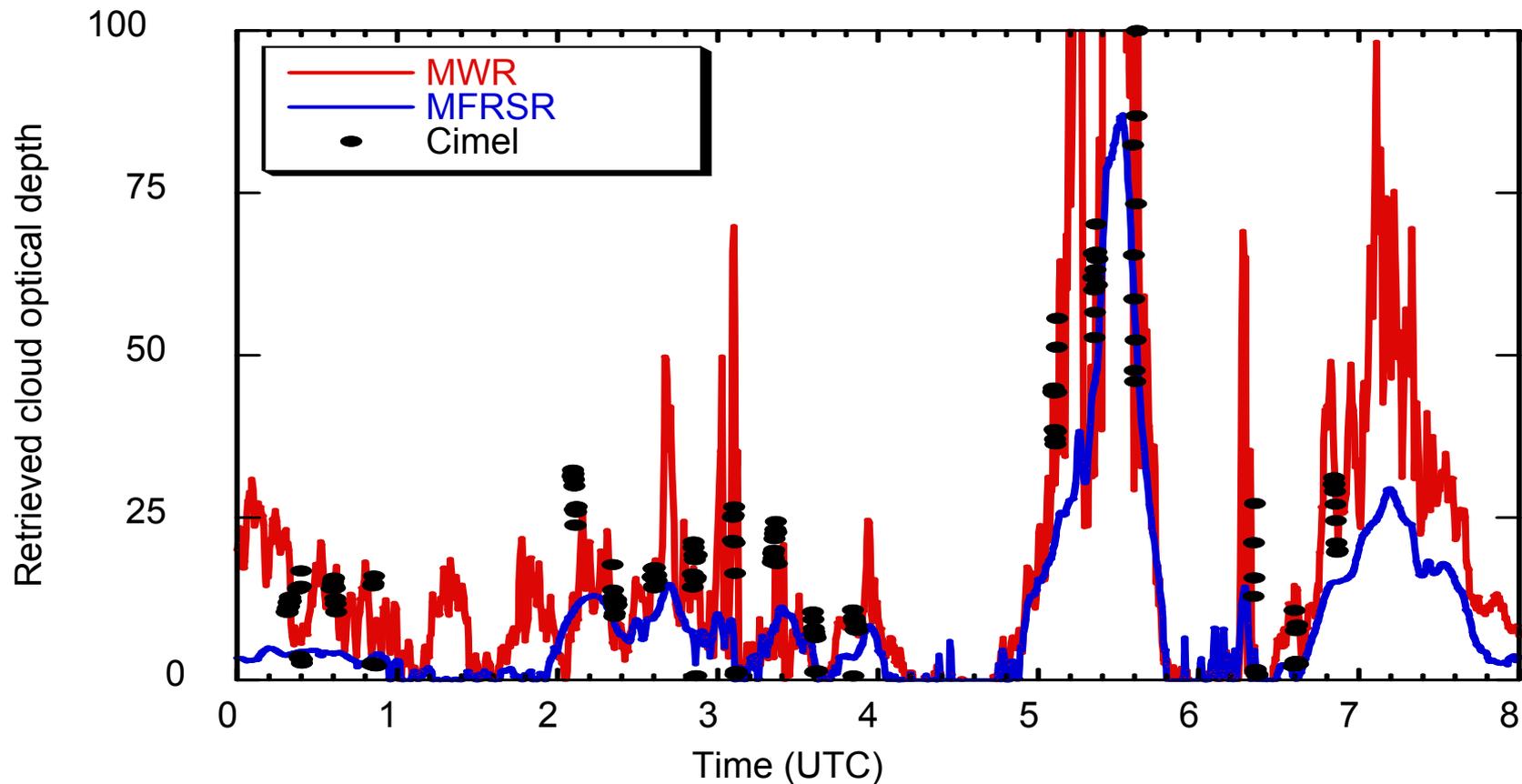
Time series of CCN



Time series of CCN over Total Particle #



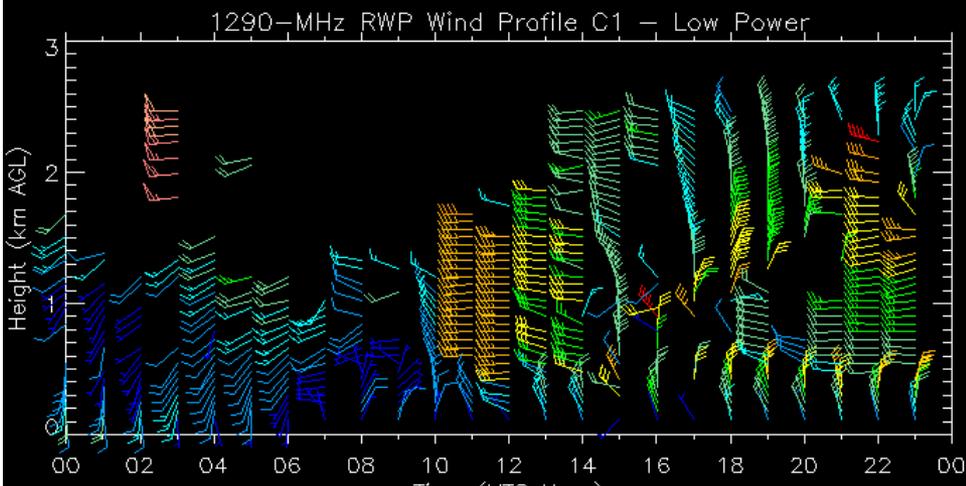
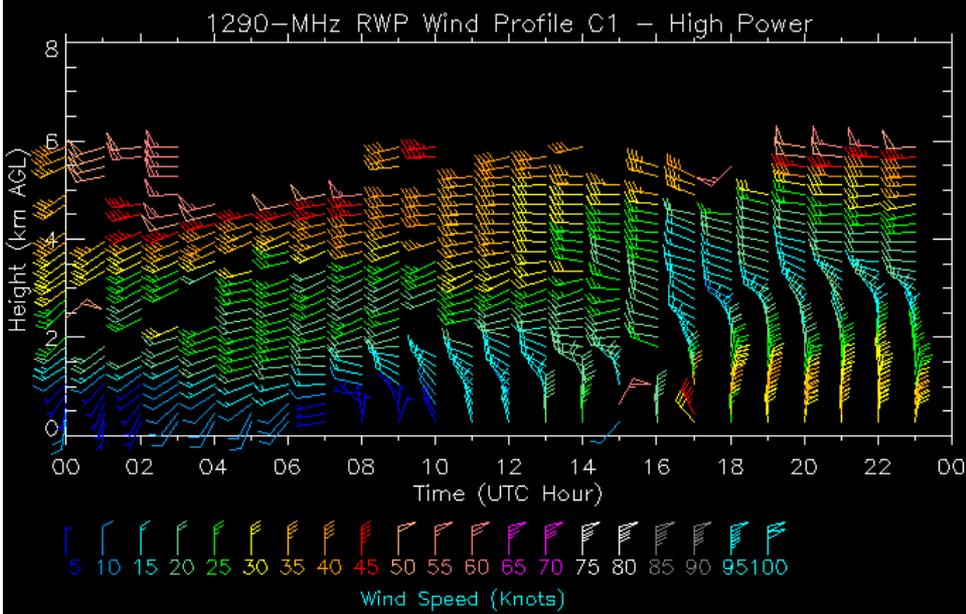
Cloud optical depth - one example from 2008/07/09 in the AMF China



Christine Chiu

Radar Wind Profiler (1290 MHz)

Sep 17 – Dec 28



Instrument	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1290 RWP								
			29					



Prof. Huang and Zhang
Lanzhou University



AAF Instruments

Radiation (SKYRAD)

- **Precision Spectral Pyranometer (PSP)**
- **Precision Infrared Radiometer (PIR)**
- **Shaded Black & White Pyranometer (B/W)**
- **Shaded Precision Infrared Pyrgeometer (PIR)**
- **Normal Incidence Pyrheliometer (NIP)**
- **Infrared Thermometer (IRT)**

Surface Meteorological Tower (SMET) Instruments

- **Optical Rain Gauge (ORG)**
- **Anemometers (WND)**
- **Temperature/Relative Humidity Sensor (T/RH)**
- **Barometer (BAR)**
- **Present Weather Detector (PWD)**

Stand-Alone Instruments

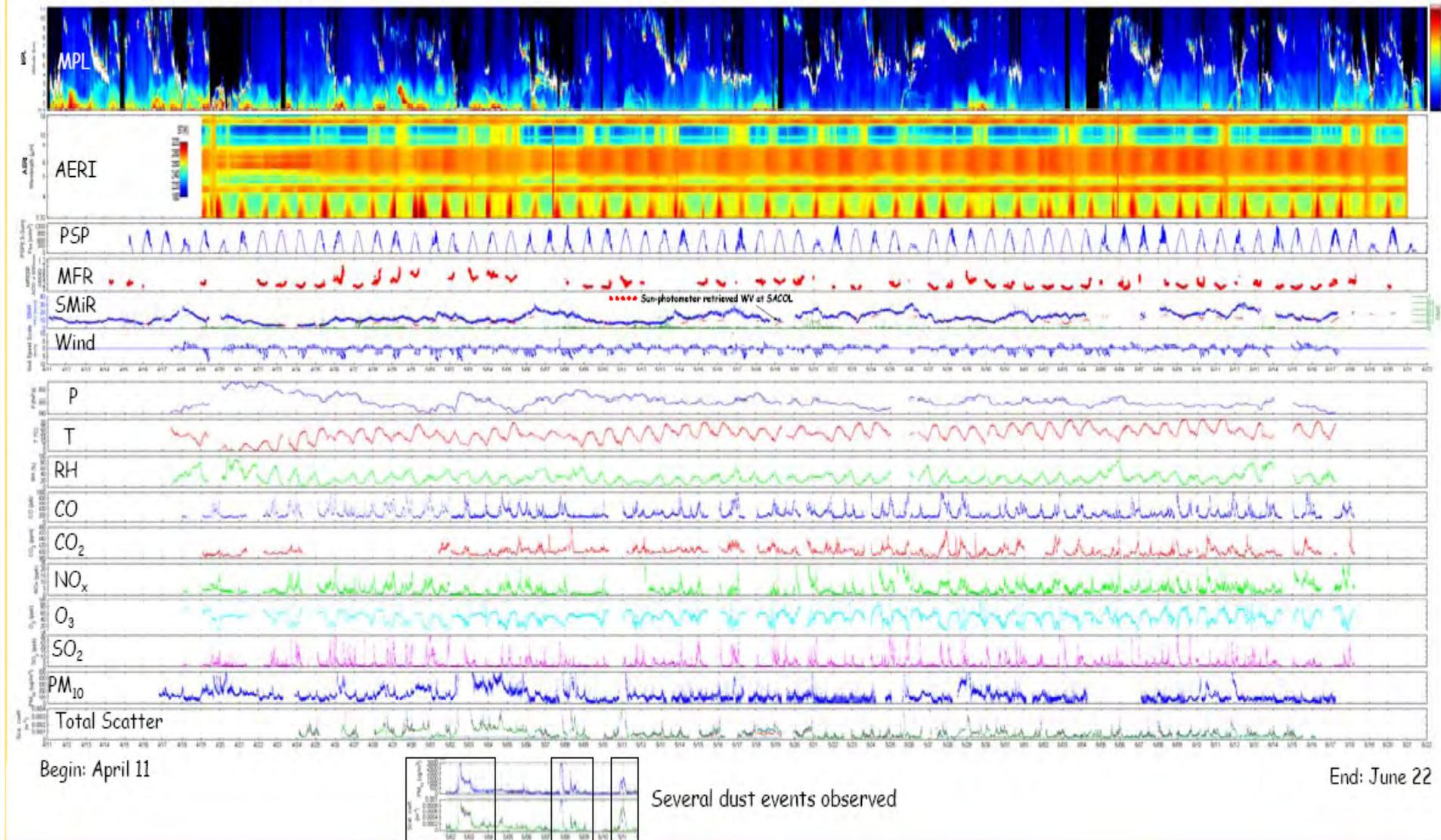
- **Microwave Radiometer (MWR)**
- **Micropulse Lidar (MPL)**
- **Tethered Balloon**
- **Atmospheric Emitted Radiance Interferometer (AERI)**
- **Total Sky Imager (TSI)**
- **Standard lamp Li-Cor**

Aerosol Observation System (AOS)

- **Aethalometer**
- **SMPS**
- **APS**
- **Nephelometer x 4**
- **TEOM aerosol chemistry**
- **TEOM-ACCU**
- **Trace Gas sampling**
- **Particle Photometer**

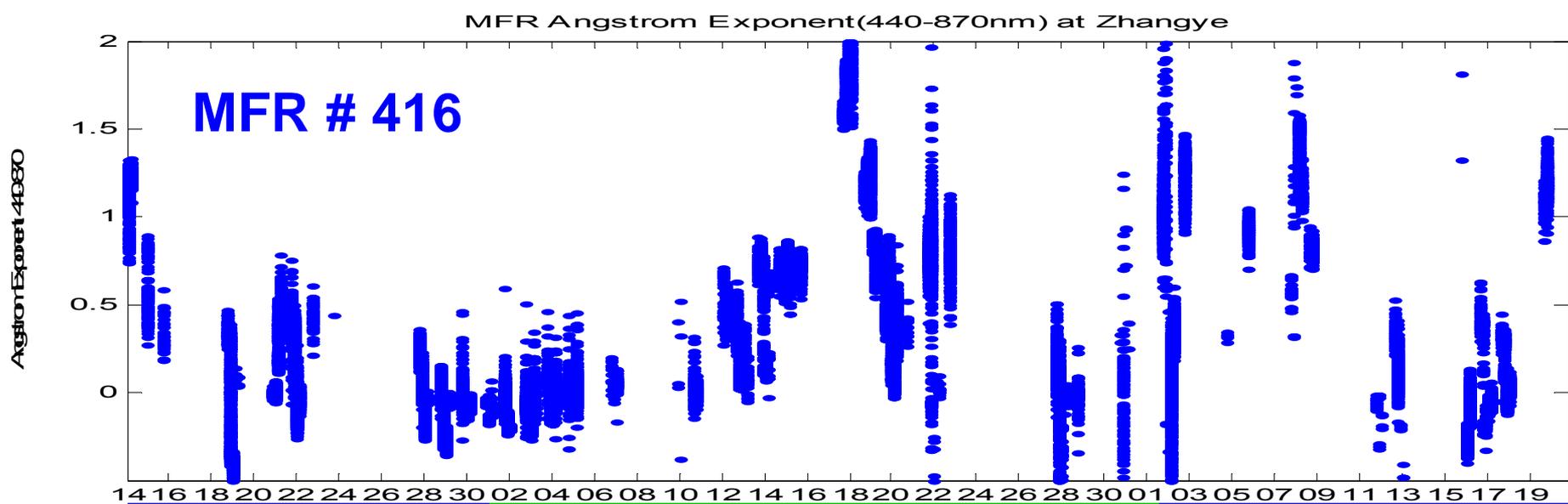
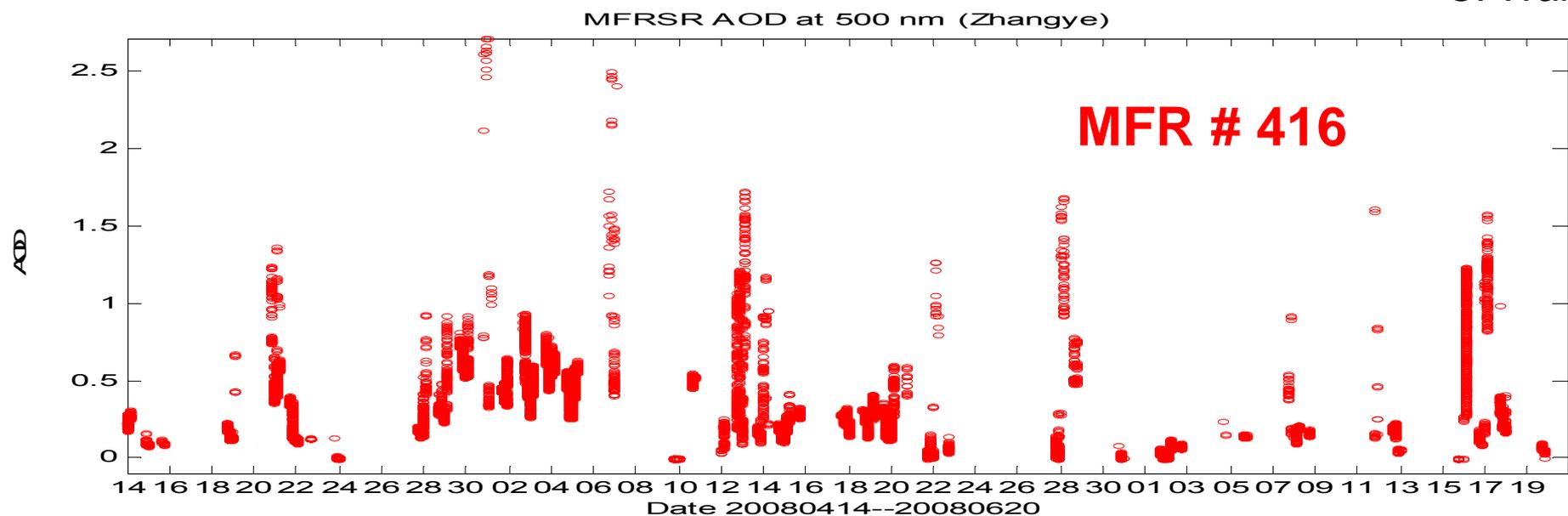
Time Series of Data from AAF

3. Selected time series



Aerosol Optical Depth and Angstrom Exponent Derived from MFR Zhangye from Apr 14-June 20

C. Wang



April May June

Summary of Dust Events in spring of 2008

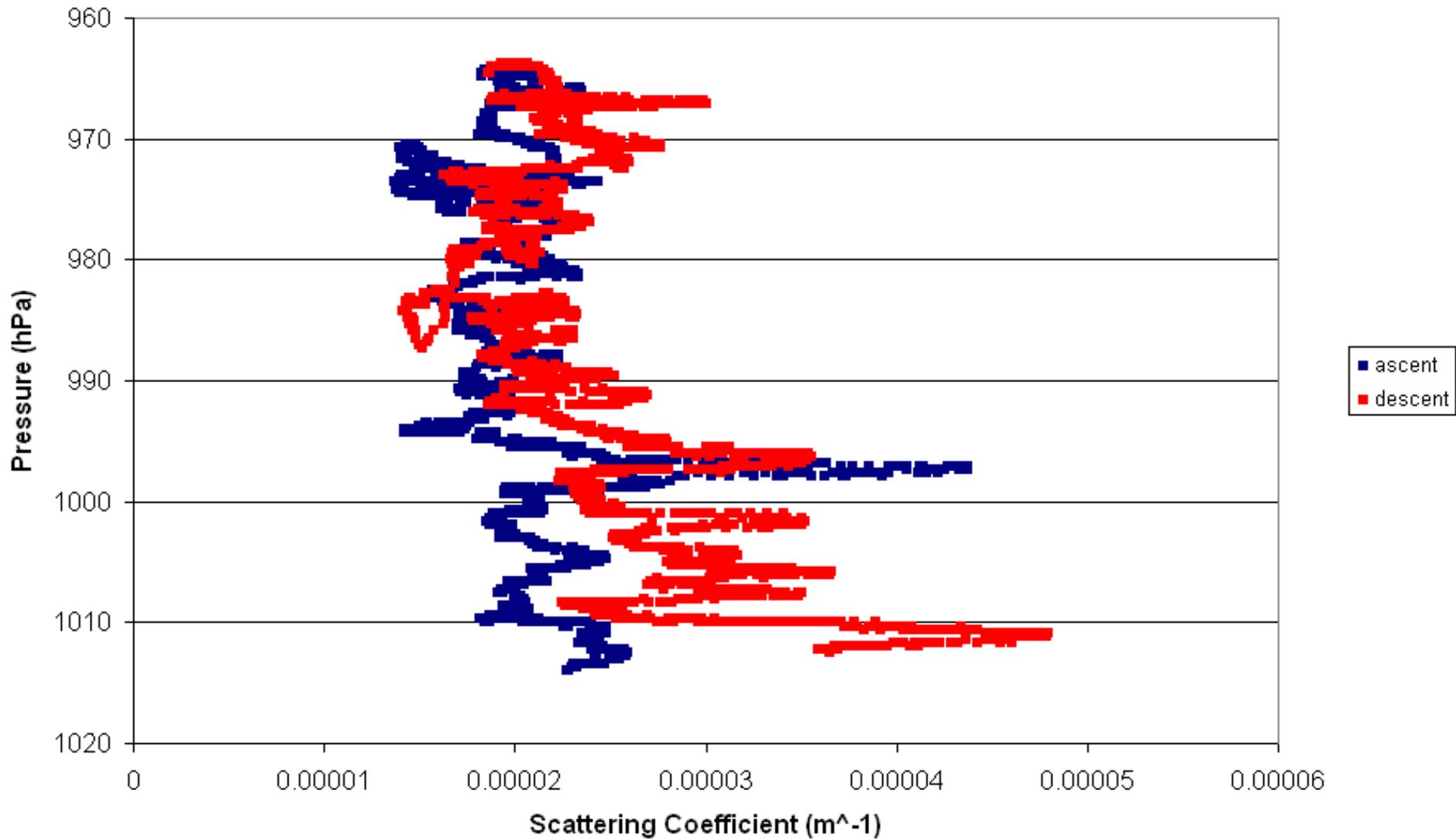
Covered period	Source	Path	Incidence	Utmost Intensity	Surface Synoptic system
4.17--4.25(17—21 Mongolia, 17--25Taklimakan Deserts)	44218,44282,44292 (Mongolia)	West, North	Mongolia//Basin of South Xinjiang, West Gansu, West Qinghai	Heavy Dust Storm	Mongolia Cyclone Cold High
4.28--5.3	44218 (Mongolia)	Northwest, North	Mongolia//Inner Mongolia, Jilin, Basin of South Xinjiang, West Gansu, West Qinghai	Heavy Dust Storm	Mongolia Cyclone Cold High
5.19--5.20	44282(Mongolia)	Northwest	Mongolia//Inner Mongolia, Hebei, Beijing, Shan'xi	Heavy Dust Storm	Mongolia Cyclone
5.25--5.28	44373(Mongolia)	Northwest	Mongolia// Inner Mongolia, Hebei, Beijing, Ningxia, Shan'xi, Jilin, Heilongjiang	Heavy Dust Storm	Mongolia Cyclone
5.28--5.31	44373,44341(Mongolia)	Northwest	Mongolia//Inner Mongolia, Ningxia, Shan'xi, Hebei, Tianjin, Liaoning, Shandong, Henan// Korea Peninsula, Japan	Heavy Dust Storm	Cold High

Tethered-Balloon Measurements



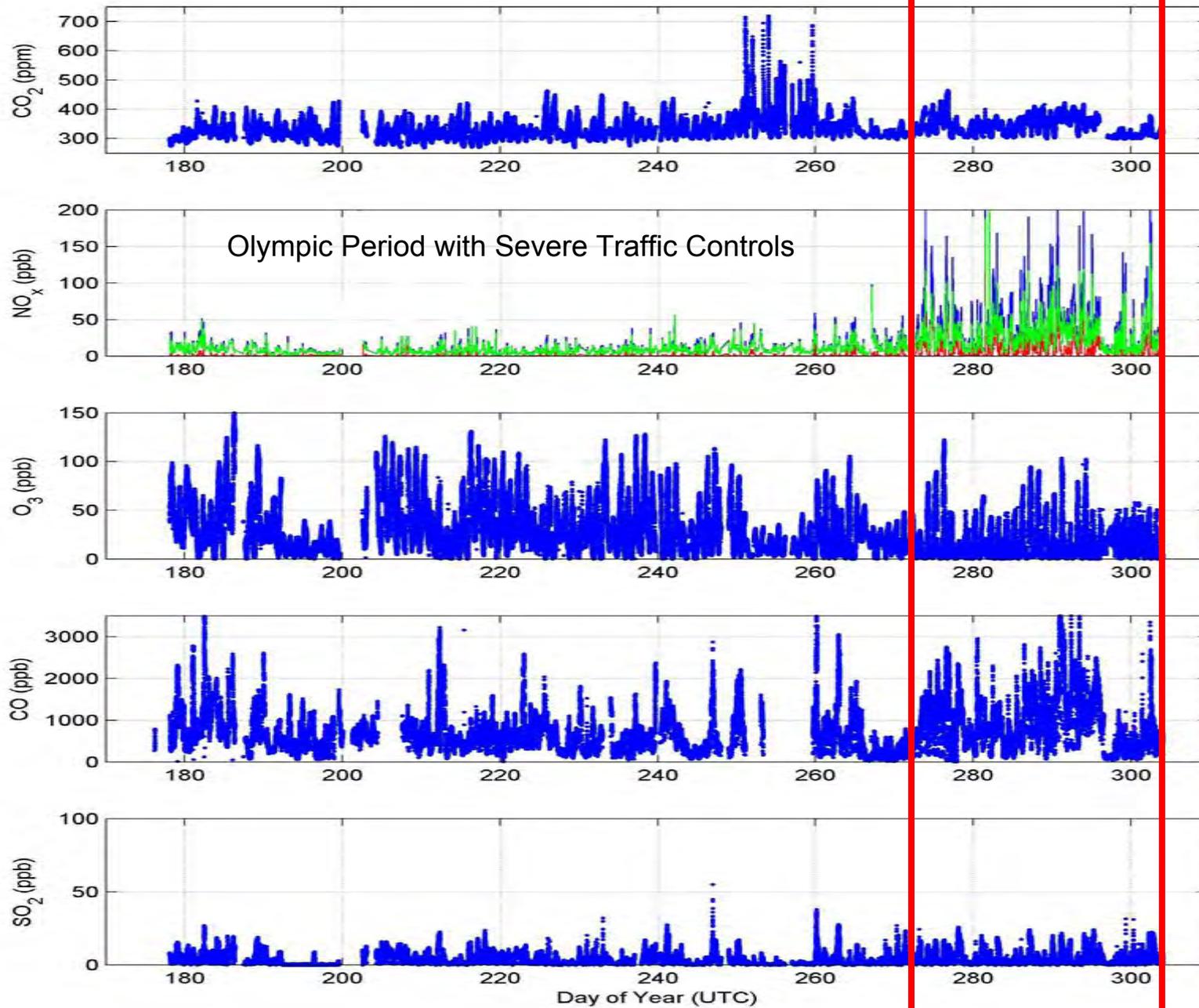
Same day as previous slide, more wind in the afternoon as well as nearby aerosol sources, sky was a little hazy

March 27th, pm launch, Xianghe

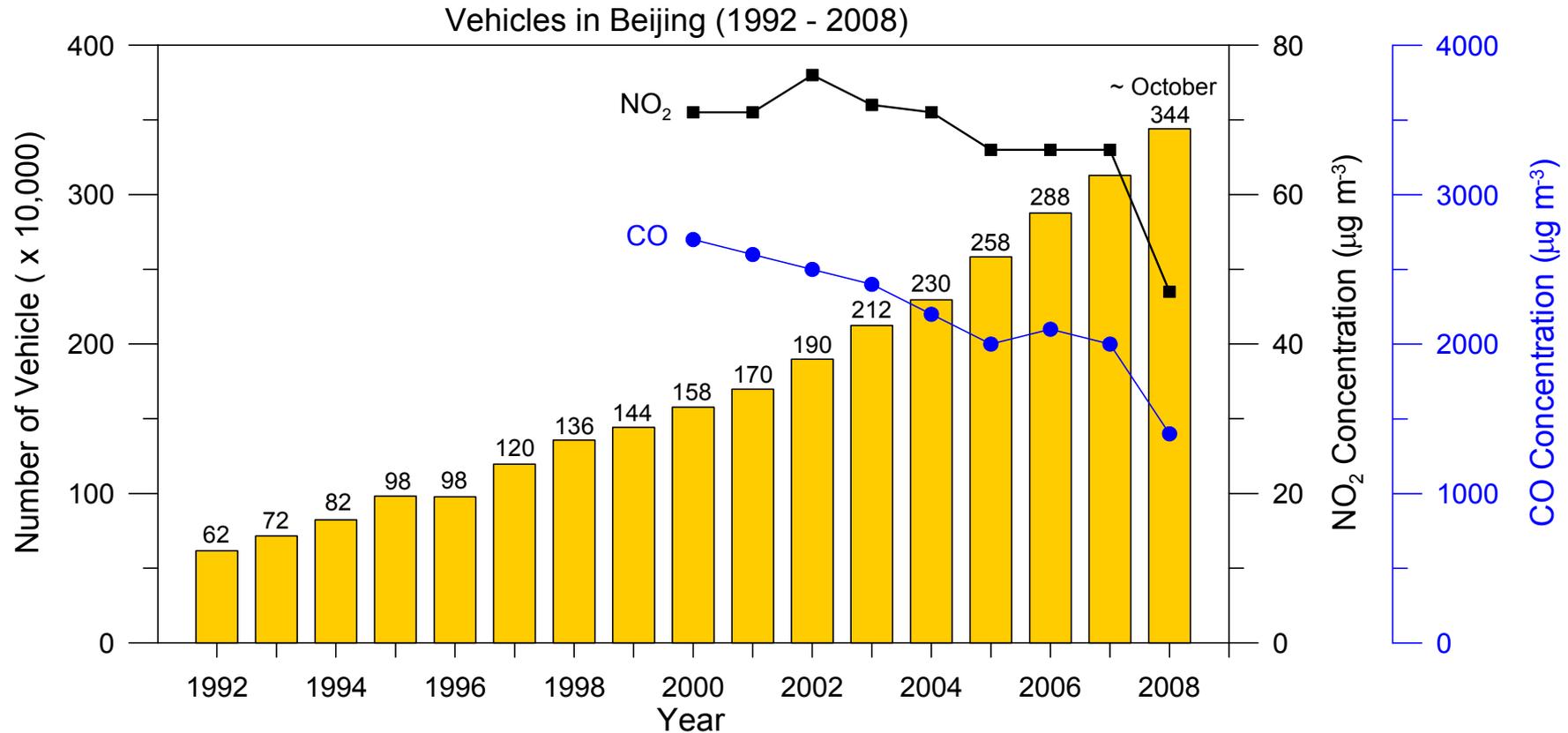


Xianghe Observatory



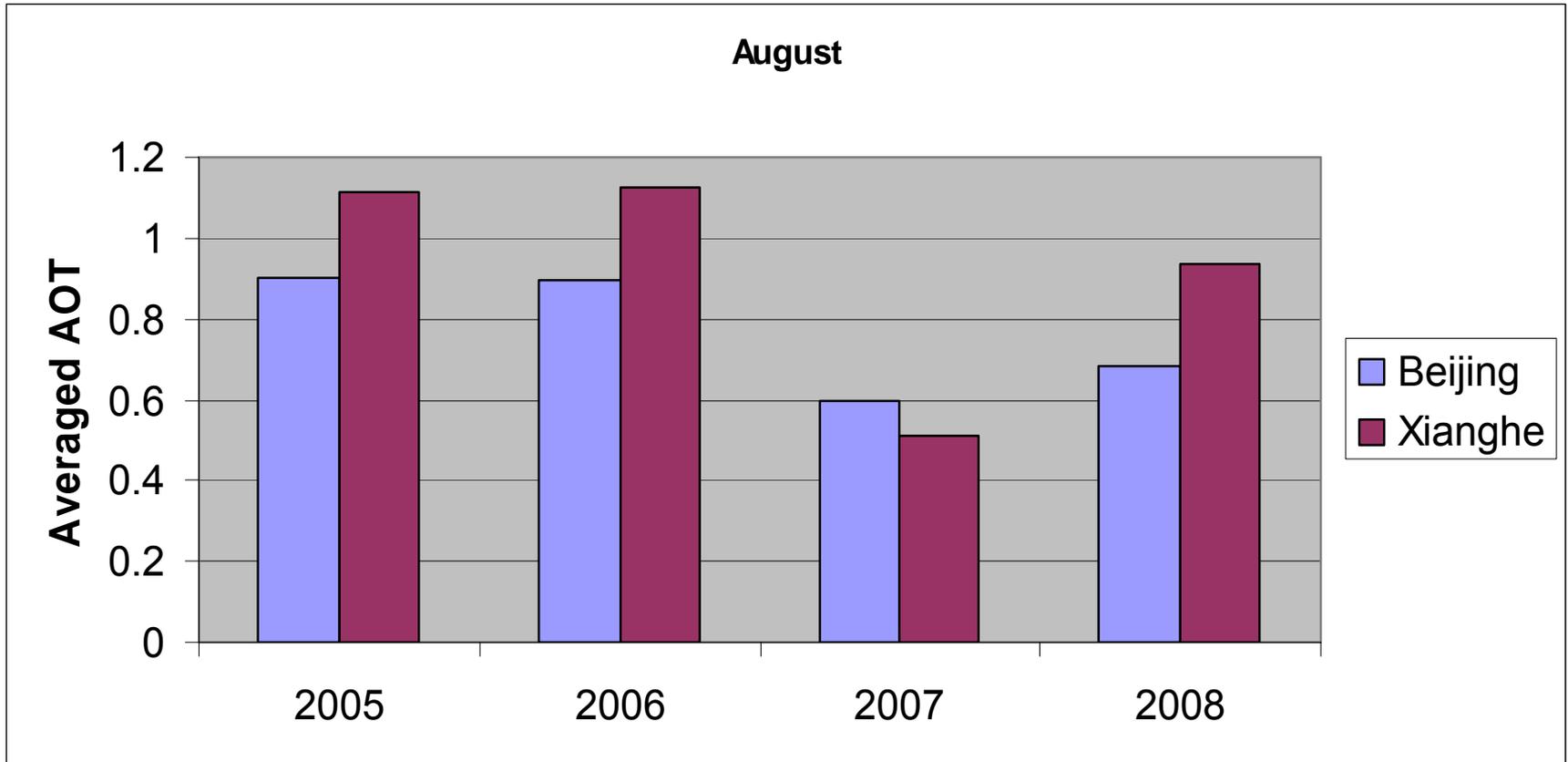


Number of Vehicles and Air Quality



[Source] Beijing Traffic Management Bureau and Ministry of Environmental Protection of the People's Republic of China

Comparison of August Monthly-Mean AOD in Beijing and Xianghe



Taihu Observator

Wuxi



Suzhou

Shanghai

Hangzhou

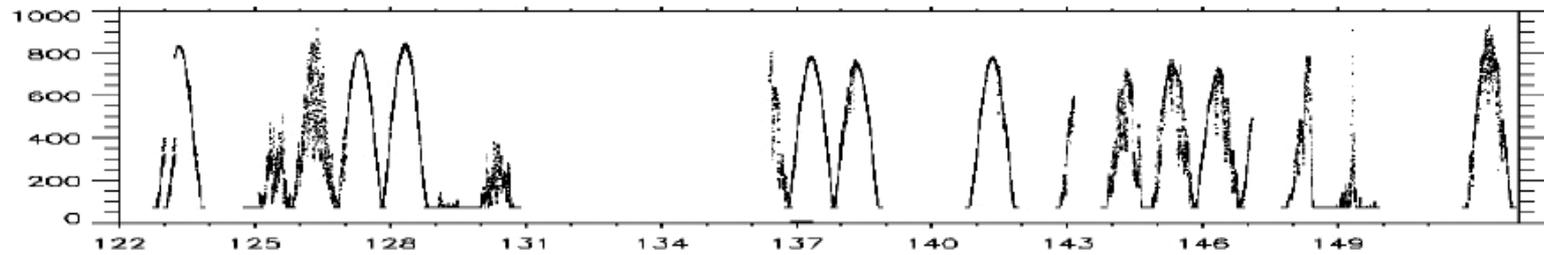




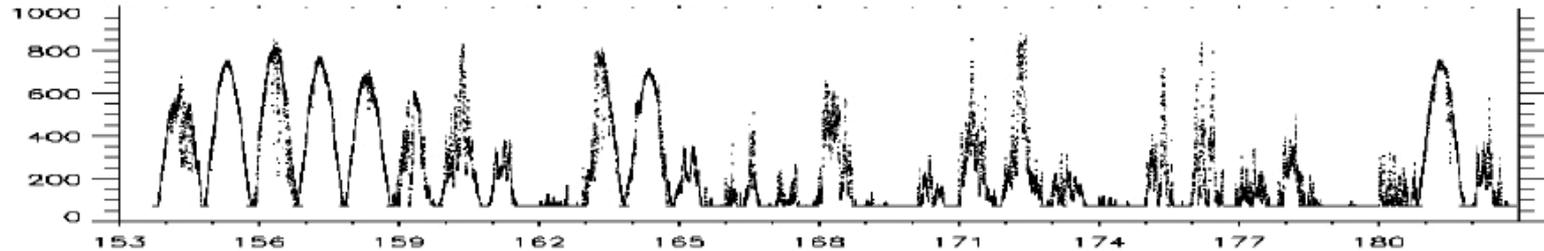
Taihu Instrumentation List 2008

Instrument	Parameters	Units	Temporal Resolution	Time Period
Cimel sunphotometer	AOD; SSA; Angstrom exponent; size distribution;	none, none none $\mu\text{m}^3/\mu\text{m}^2$	15 minutes	Jan.1/08-Oct.2/08 (V2.0) Oct.7/08-Dec.31/08 (V1.5)
ASD spectroradiometer	solar spectral radiances (350-2500 nm, 1-nm resolution)	$\text{W m}^{-2} \text{ nm}^{-1} \text{ sr}^{-1}$	1 minute	2008: Apr. 25 - May 19 Jul. 19 - Dec. 31
MFRSR	broadband fluxes; spectral fluxes (414,495,613,671,867,939 nm)	W m^{-2} $\text{W m}^{-2} \text{ nm}^{-1}$	1 minute	Apr. 27/08 - Dec.31/08
B&W pyranometer Norm. incid. pyrhelimeter PIR pyrgeometer PAR Lite sensor	diffuse solar fluxes ; direct solar fluxes ; longwave fluxes; photosynthetic photon flux	Wm^{-2} Wm^{-2} Wm^{-2} Wm^{-2}	1 minute	Jan.01/08 - May 23/08
Micro-pulse Lidar	total lidar attenuated backscatter profile; linear depolarization ratio		1 - 3 minutes	2008: Mar. 24 - May 3 May 16 - Aug. 4 Aug. 8 - 29
Microwave Radiometer	temperature profile; RH profile; vapor density profile; liquid water profile time series of: surface pressure ;RH ; surface T ; T (IR) ; cloud base height; precipitable water; liquid water; rain	K % g m^{-3} g m^{-3} mb,% K,K km cm mm, 0=no, 1=yes	1 minute	Apr. 25/08 - Dec. 31/08
Total Sky Imager	JPEG images of daytime sky		1 minute	Apr. 24/08 - Dec. 31/08
Weather Transmitter	air pressure; air temp. ; RH; wind speed/direction; rain accumulation	mb C, % m s^{-1} , degrees mm	1 second 1 second 3 seconds 1 second	Sep. 23/08 - Dec. 31/08

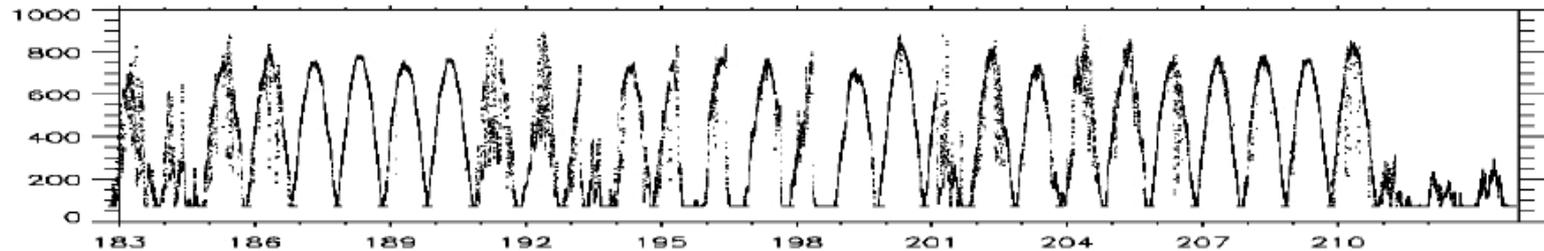
MFRSR Broadband Global Irradiance



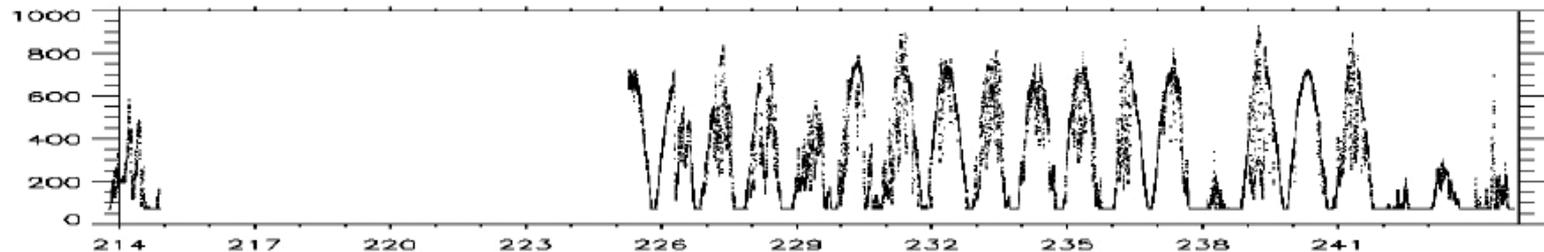
May



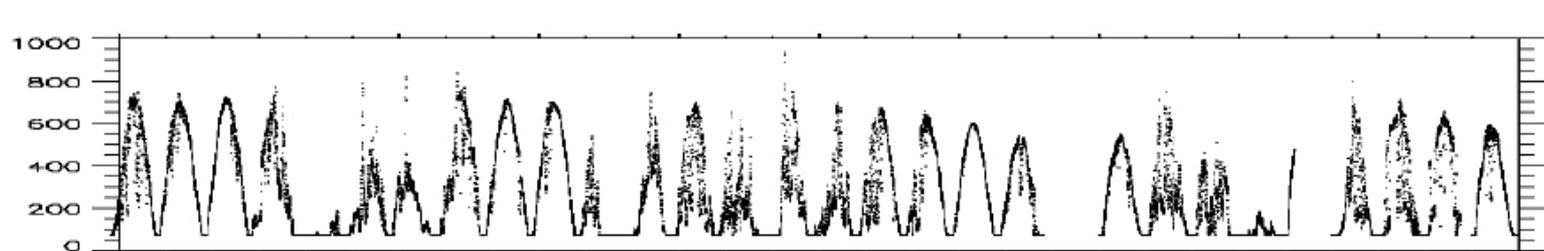
June



July

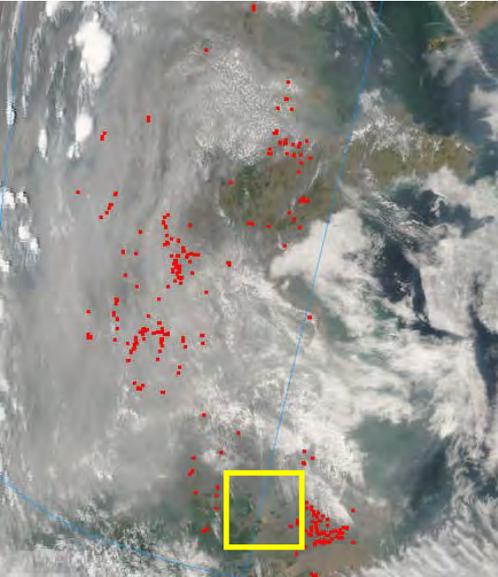
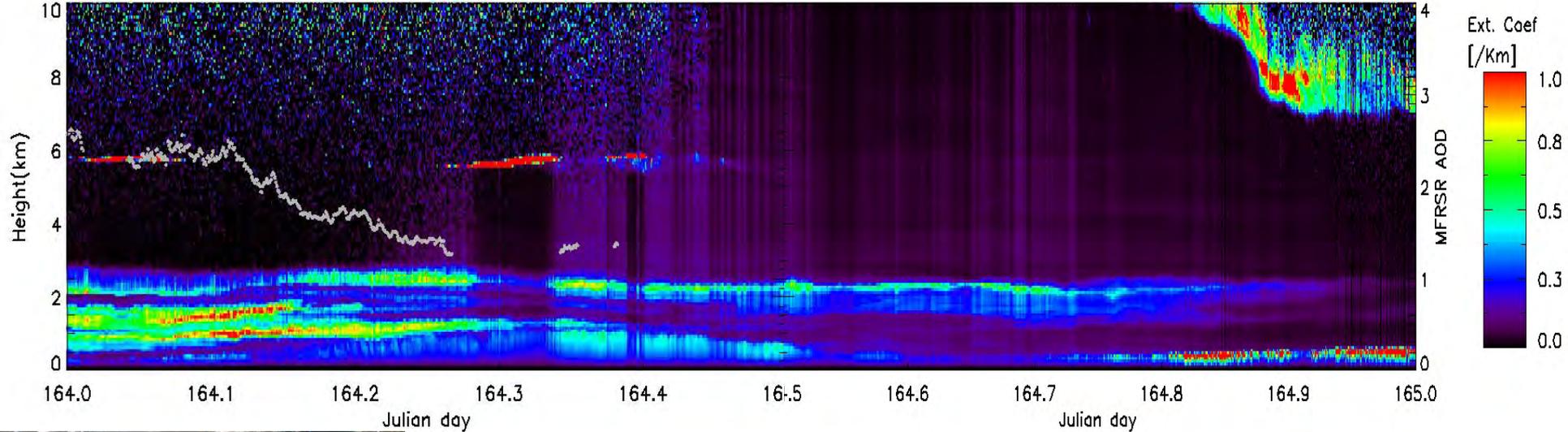


Aug



Sep

Integrated Analysis (June 12, 2008)

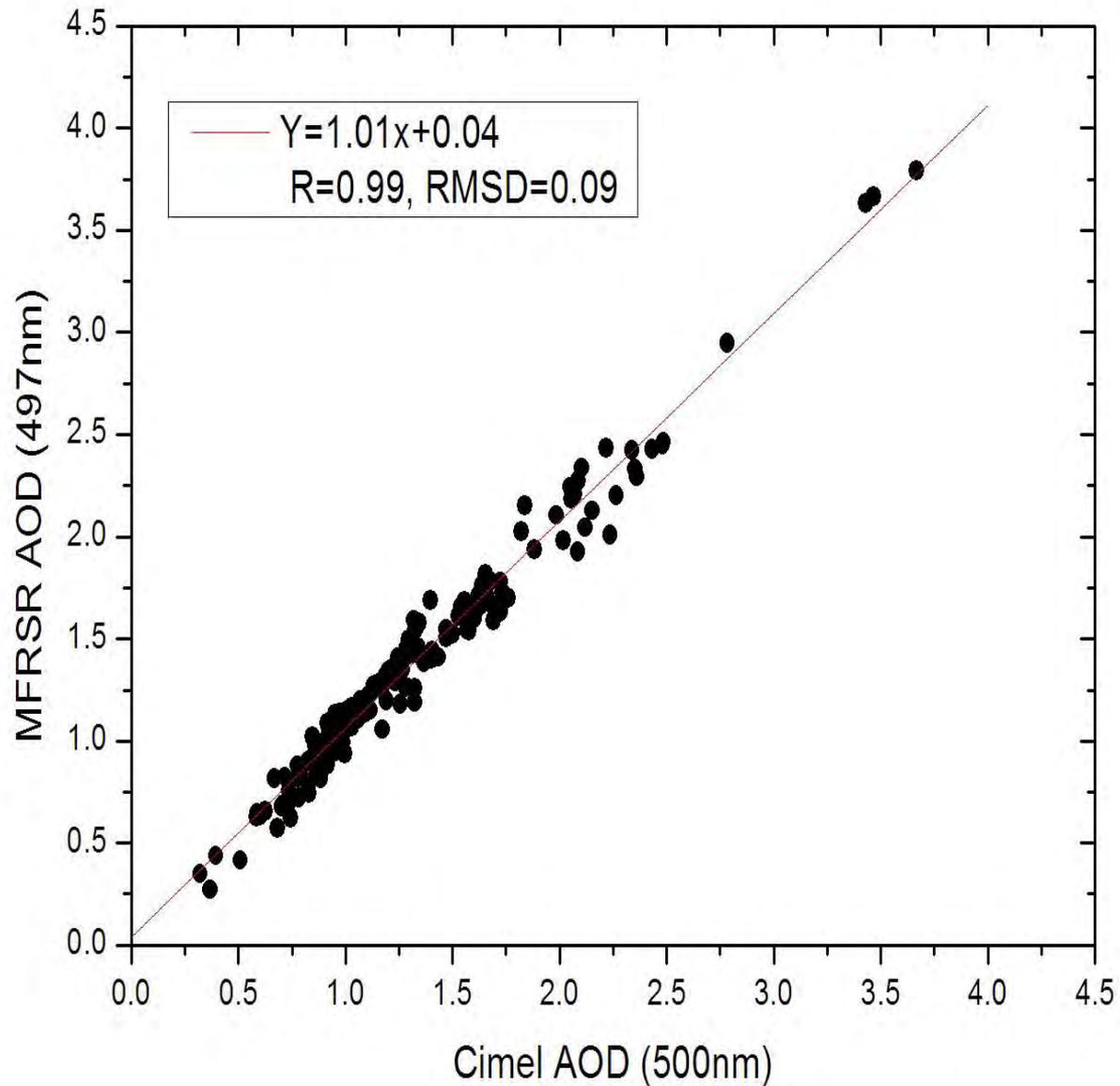


MFRSR AOD: ~ 3.0

Lidar: thick haze+smoke layer under 3km

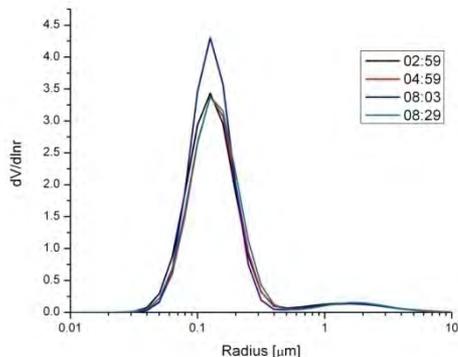
MODIS color image: hazy,
many hot spots near the lake,
small cloud sells are producing

Comparison of AOD from Cimel and MFRSR



Extinction Profile Retrieval

Aerosol volume size distribution

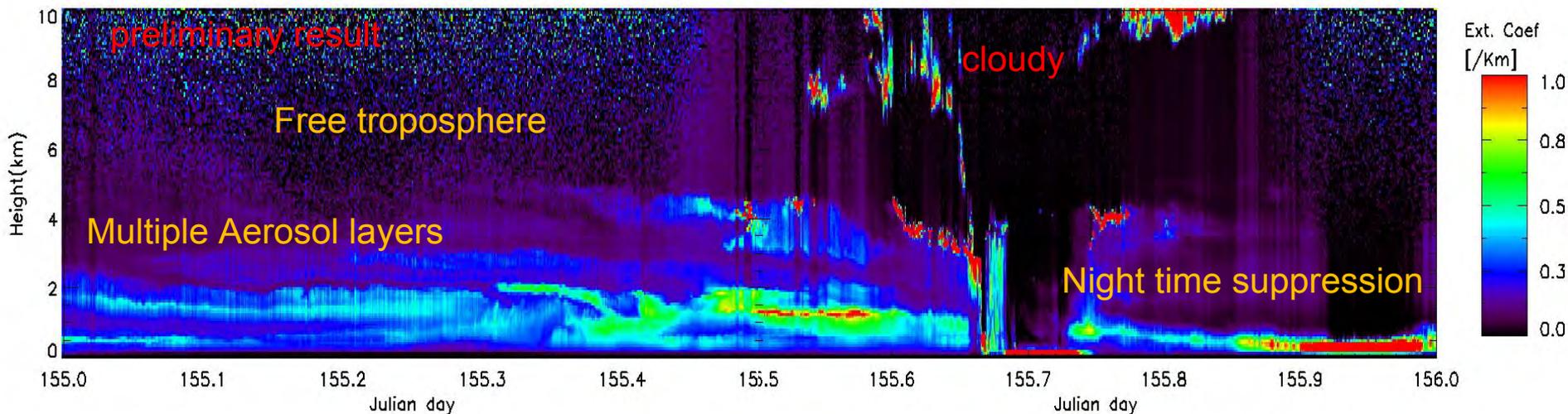


Combination: Active Lidar+ Passive Sun Photometer

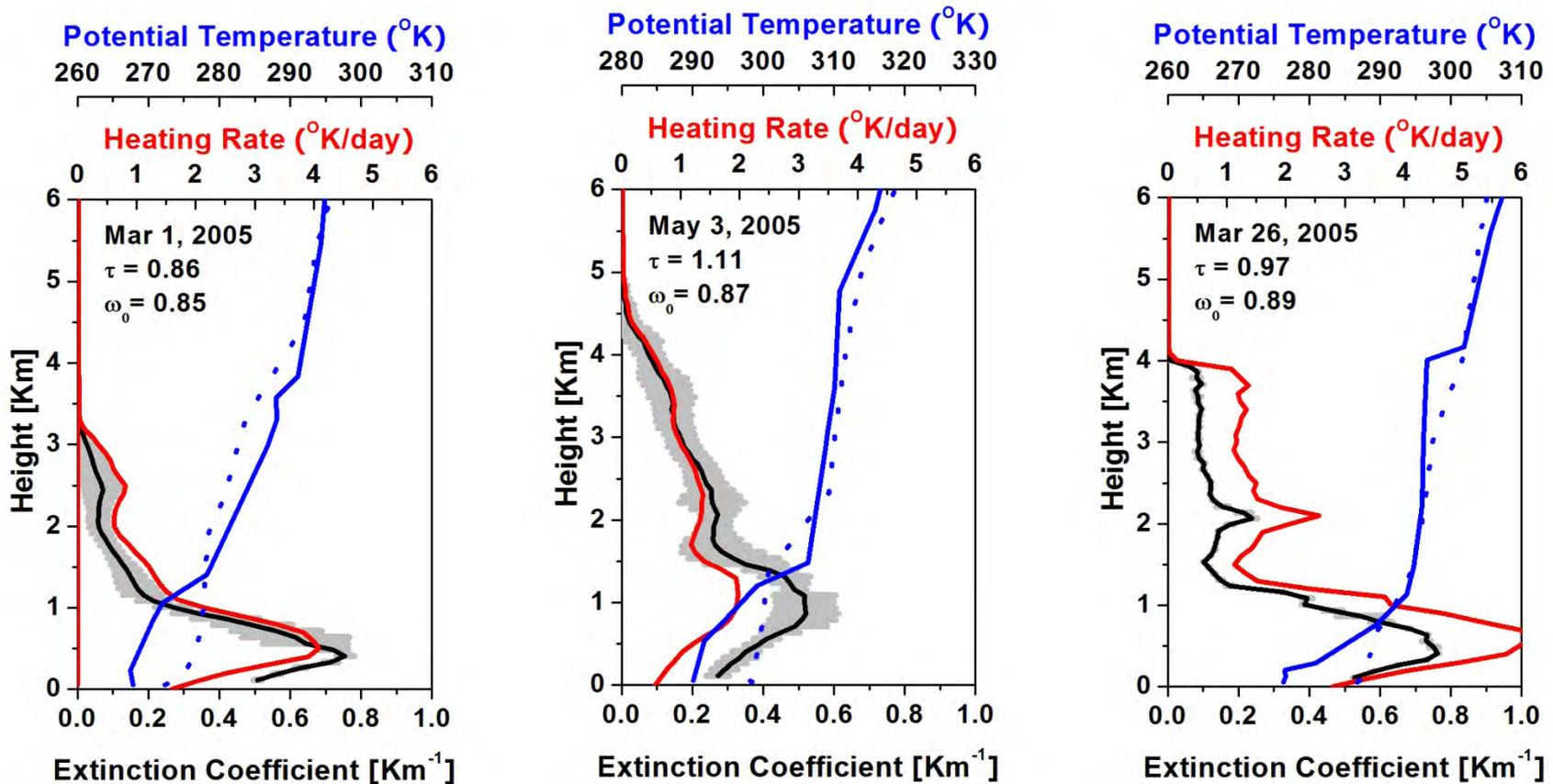
Using size distribution and refractive index from AERONET inversion products, aerosol extinction-to-backscatter ratio is calculated.

$$S_{aer} = \frac{\sigma_{aer}}{\beta_{aer}} = 67.21 \pm 2.64$$

Retrieved Extinction Profile, Taihu, 2008 June 3

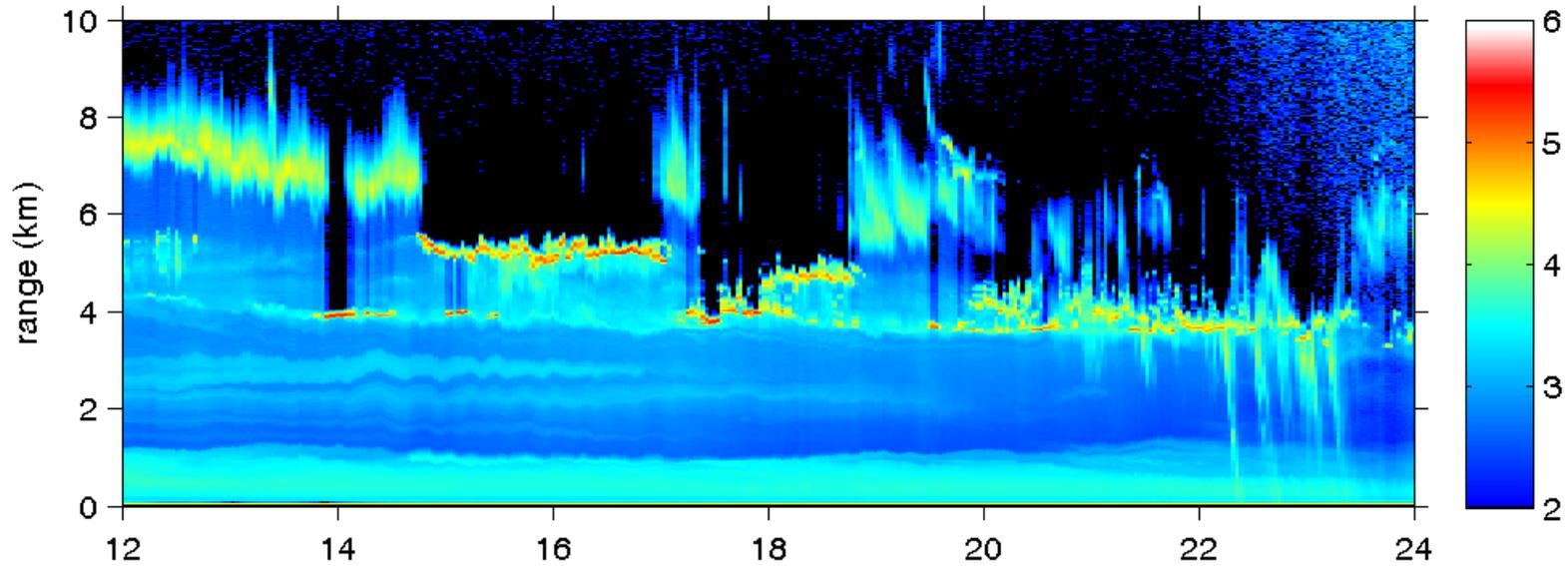


Atmospheric adiabatic heating rate

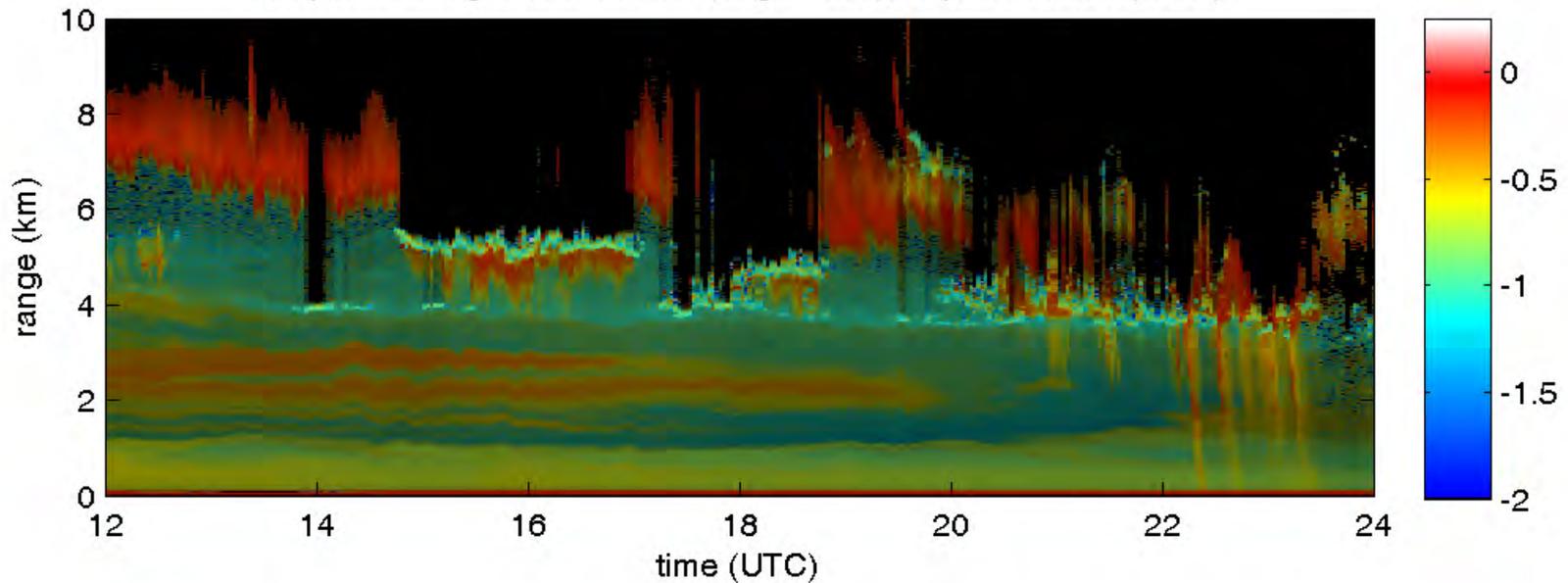


- A steep increase in the potential temperature in the upper region of the aerosol layer was found.

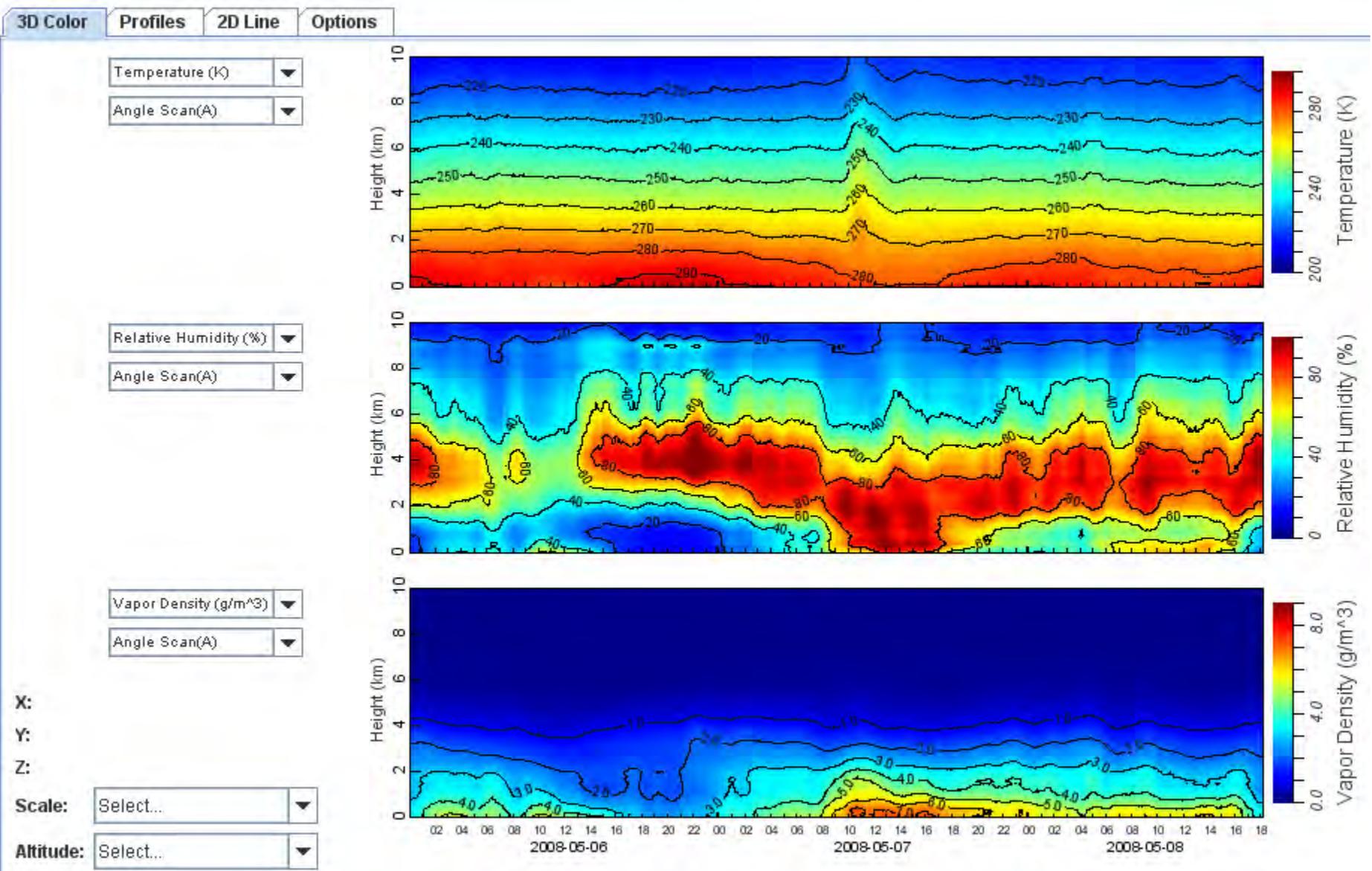
Attenuated backscatter: 2008-10-24 12-24 UTC



Composite image: backscatter (brightness), depolarization (color)



Contour plots of temperature (top panel), relative humidity (middle panel), and water vapor density (bottom panel) for the period of May 6-8, 2008.



Future Work Plan

- **Observation:**

- *To continue the operation of our existing baseline ground observation stations and nation-wide aerosol survey stations so that major types of aerosols are characterized and their temporal and spatial variations across China are quantified;*

- **Analysis:**

- *Continual and prompt analysis of all data acquired to assure data quality and consistency among all instruments deployed in China;*
- *Matching AMF and AAF data with various satellite products (aerosol, cloud, radiation and precipitation) over the region in order to identify, reduce or remove any systematic errors;*
- *Using combined ground-based, space-borne and air-borne measurements to study aerosol effects on cloud microphysics, precipitation, atmospheric circulation and regional climate.*

- **Modeling**

- *Radiative transfer modeling for 1) closure tests, 2) computing atmospheric heating rates, 3) determination of aerosol radiative impacts;*
- *Validate and improve GCM models in simulating the impact of Chinese aerosols on regional and global climate;*
- *Validate and improve a regional climate model (RCM) that incorporates aerosol-cloud interactions.*

PM Breakout Session (Rm 1)

- **1:00-3:00pm**
 - **C. Kummerow, Plans for the use of the AMF-China data - Preparatory work using ARM data from Nauru Niamey**
 - **R. Hansell, An overview of the AAF deployments and preliminary results.**
 - **W. Zhang/Z. Li, An overview of the concurrent Chinese field experiments and dust activities in western China.**
 - **K. Lee, K., Retrieval of aerosol optical depth and extinction profiles from MFR and lidar.**
- **3:00-5:00**
 - **C. Flynn, An overview of the MPL measurements at 3 locations in China.**
 - **Z. Chaudhry, Development of a balloon-borne aerosol profiling system and its application in China.**
 - **H. Shao, Retrieval of cloud number concentration from radar and relation with aerosol number concentration.**
 - **F. Niu, Analysis of aerosol indirect effects in China using satellite and ground measurements and modeling discussions of future studies and collaborations.**

Hope to see you there