Breakout Session

Integration of multiple perspectives: Aerosols

Charge

- Identify work already started (allow for short presentations)
- Identify intended work
- Identify work needed but not planned
- Develop list of potential manuscripts
- Identify any topics worthy of a small special section

DISCOVER-AQ Objectives

1: Relate column observations to surface conditions for aerosols….

A. How well do column and surface observations correlate?

B. What additional variables (e.g., <u>boundary layer depth, humidity, clouds</u>).. appear to influence these correlations?

C. On what spatial scale is information about these variables needed (e.g., 5 km, 10 km, 100 km) to interpret column measurements?

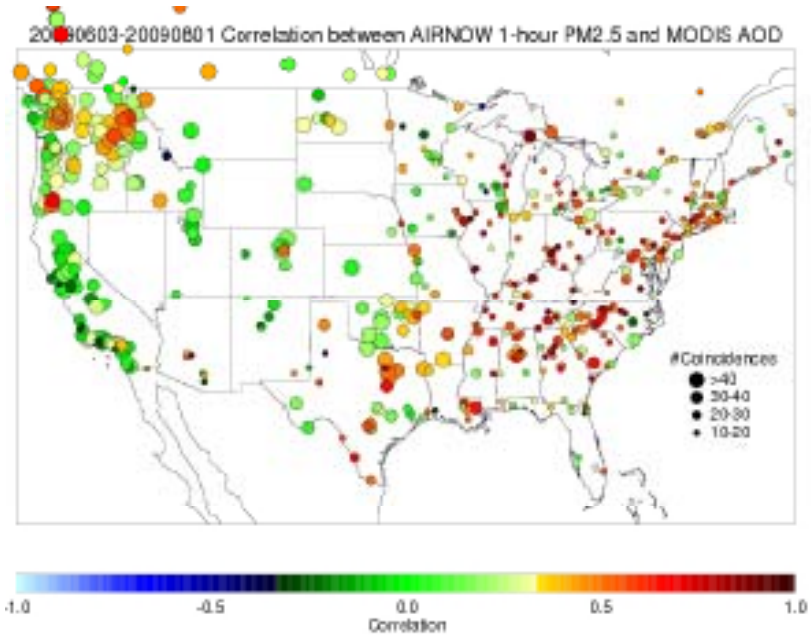
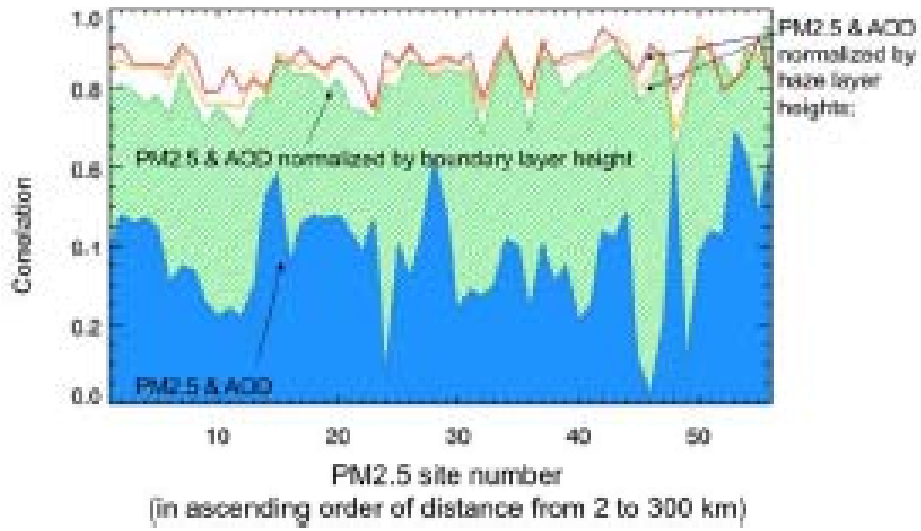


Figure 1. Correlation between MODIS AOD and surface PM2.5 for 3 June - 1 August 2009. (http://www.star.nesdis.noaa.gov/smcd/spb/aq/)



A. Chu et al.

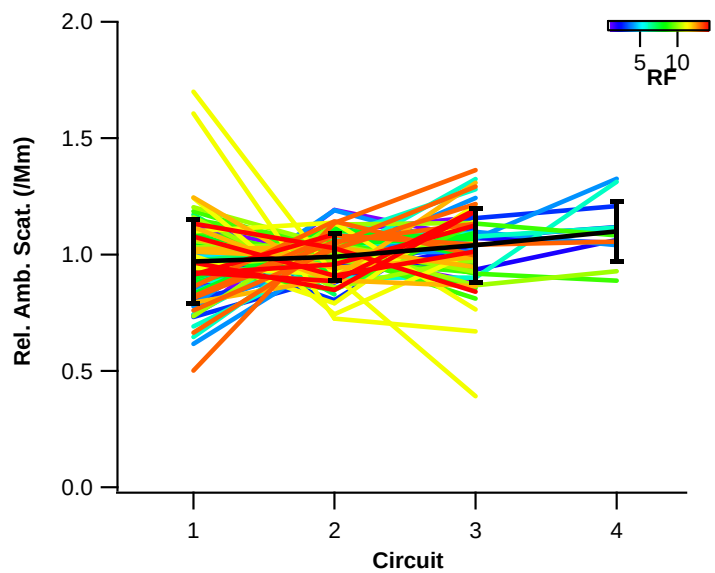
DISCOVER-AQ Objectives

2: Characterize differences in diurnal variation of surface and column observations for key … aerosols

A. How do column and surface observations differ in their diurnal variation?

B. How do emissions, boundary layer mixing, synoptic transport, and chemistry interact to affect these differences?

C. Do column and surface conditions tend to correlate better for certain times of day?



A. Beyersdorf et al.

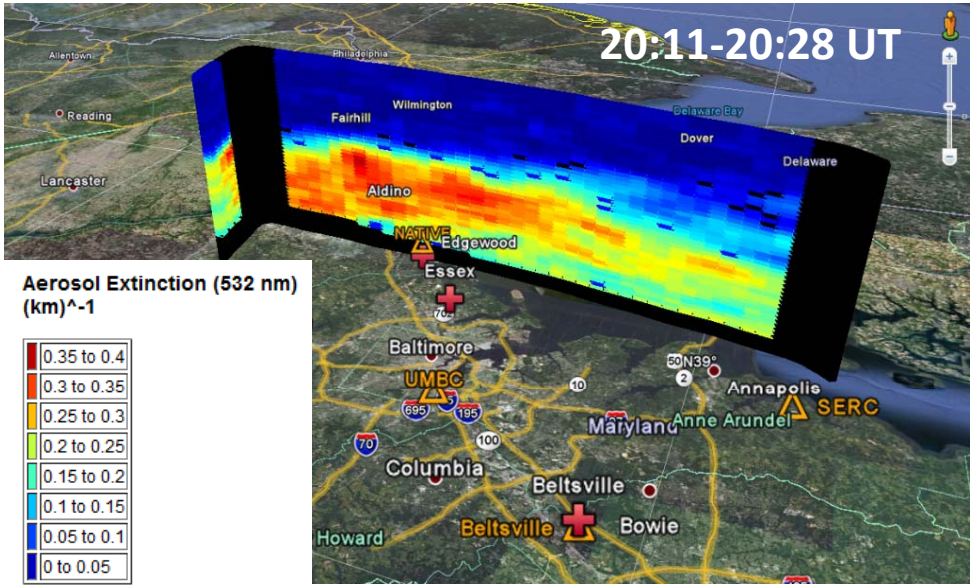
DISCOVER-AQ Objectives

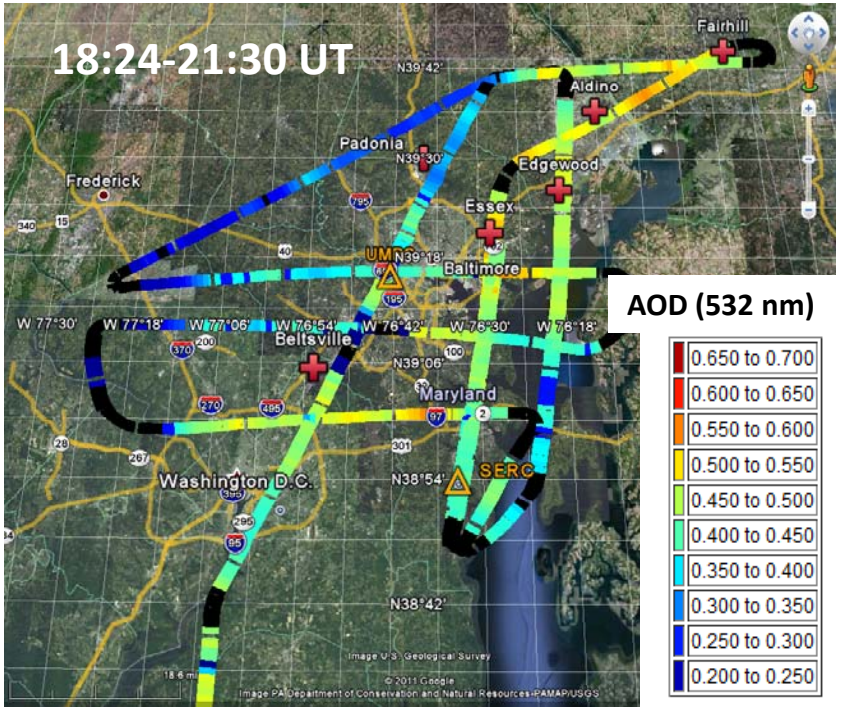
3: Examine horizontal scales of variability affecting satellites and model calculations

A. How do different meteorological and chemical conditions cause variation in the spatial scales for urban plumes?

B. What are typical gradients in key variables at scales finer than current satellite and model resolutions?

C. How do these fine-scale gradients influence model calculations and assimilation of satellite observations?





DISCOVER-AQ Aerosol Data & Guesstimates

Site	POC	AOD	PM2.5	Scat	Abs	Ext	Bscat Profiles	dPol	f(RH)	BC	Size	Composition	PBL Height
MODIS	Chu	X											
OMI	X. Liu/ Torres	X											
MISR	Kahn	X											
GOES	Kondragunta	X											
Calipso	Ferrare						X	X					X
UC-12 HSRL	Ferrare/ Hostetler	X				X	X	X					X
P-3B LARGE	Anderson/ Thornhill	X	X	X	X	X			X	X	X	X	X
UMD Cessna	Dickerson/ Stehr	X		X	X	X				X			
Beltsville	Joseph	X	X	X	X	X	X						X
Fairhill	Tsay	X	X	X	X	X	X				X		X
UMBC	Hoff/ Delgado	X	X	X			X						X
MDE Sites	Hains	X	X										
NATIVE/MU Edgewood	Martins/ Clark	X	X, profiles?	X			X						X
MPL	Berkoff						X	X					X
Ship	Jordan	X					X					X	X
AERONET	Holben	X			X						X		
GOCART	Chin	X	X	X	X	X	X		X	X	X	X	X
GEOS-5	Silva	X	X	X	X	X	X		X	X	X	X	X
WRF-Chem	Pickering/ Cook	X	X	X	X	X	X		X	X	X	X	X
NU-WRF	Tan/Tao	X	X	X	X	X	X		X	X	X	X	X

Groups Addressing Aerosol Issues

NASA Langley
- LARGE– a) f(RH)/composition; b) transport and variability; c) AERONET vs. In Situ
- HSRL – PBL/Scaling Heights, Spatial Variability

NASA GSFC
- AERONET – a) AERONET/In Situ; b) Cloud Interactions; c) Overview of Aerosol Retrievals
- MODIS – a)PM2.5 relationship to MODIS (Chu); b) validation of MODIS high res data vs. DAQ
- MODELING—a) GEOS-5 MODIS assimilation for PM2.5; b) GOCART/NU-WRF AOD vs. surface PM2.5; c) Chatfield Retrieval paper; d) CMAQ evaluation (UMD/EPA/Pickering)

UMBC—a)Variability, bay breeze, source apportionment, b) optical properties vs. microphysics; MPL—a) PBL/Scaling Heights, HSRL/MPL comparison, spatial variability

UMD—a) Evaluate GOES AOD vs. in situ; b) Regional context of observations; c) Aerosol speciation

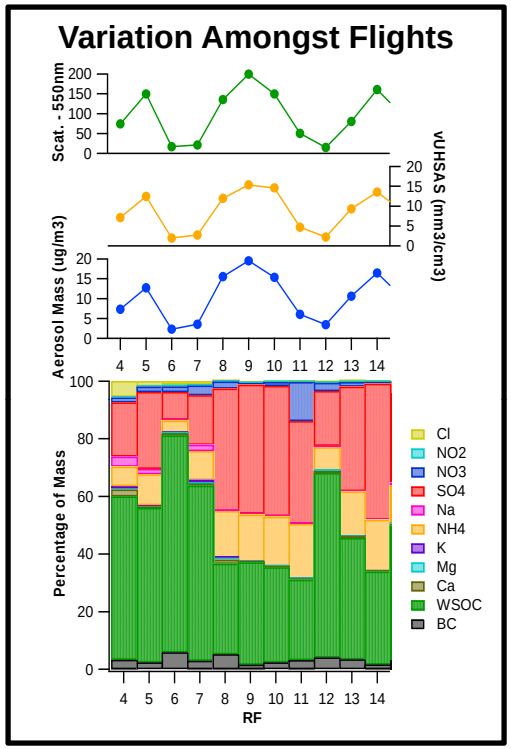
Howard—a) PBL properties – COLABORATIVE ANALYSES --have CCN data

Millersville—

NATIVE—

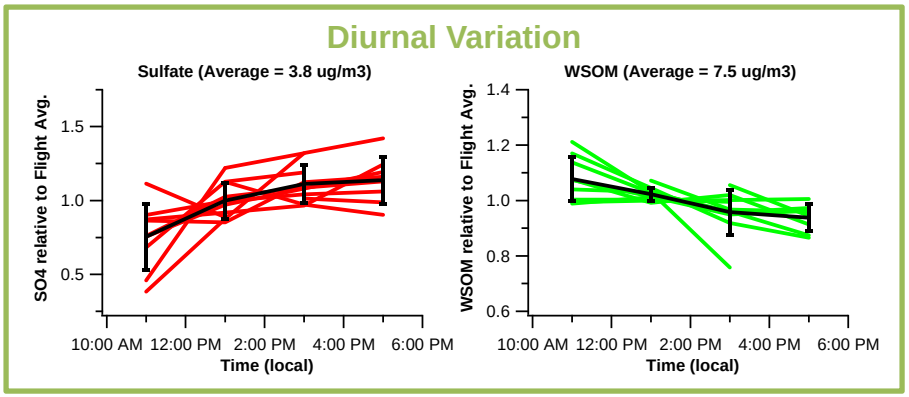
---OVERVIEW of GROUND SITES

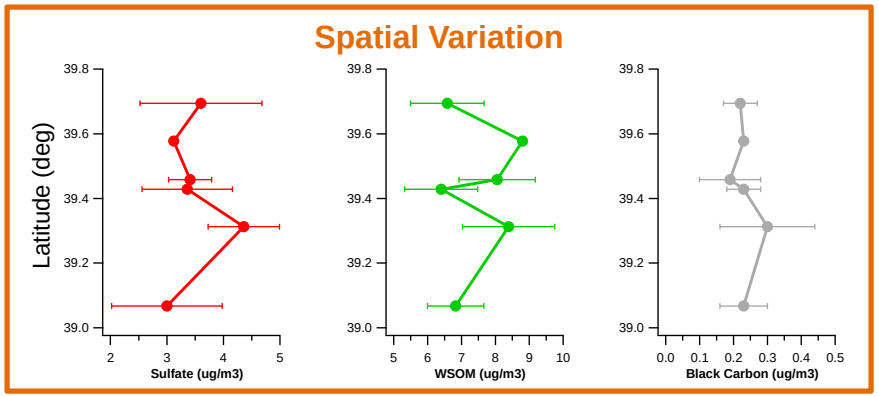
P-3B Aerosol Composition



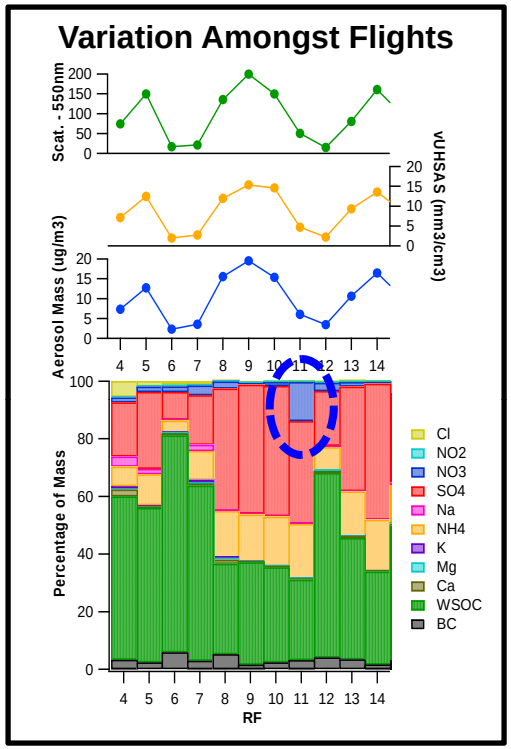
Aerosol composition measured with a PILS and SP2

- In general, 60% organics and 40% ammonium sulfate.
- **Variation Amongst Flights:** Composition varied with aerosol loading with ammonium sulfate dominating on highly polluted days.
- **Diurnal Variation:** Sulfate increased during the day while organics decreased.
- **Spatial Variation:** Essex had the highest loadings for most compounds.

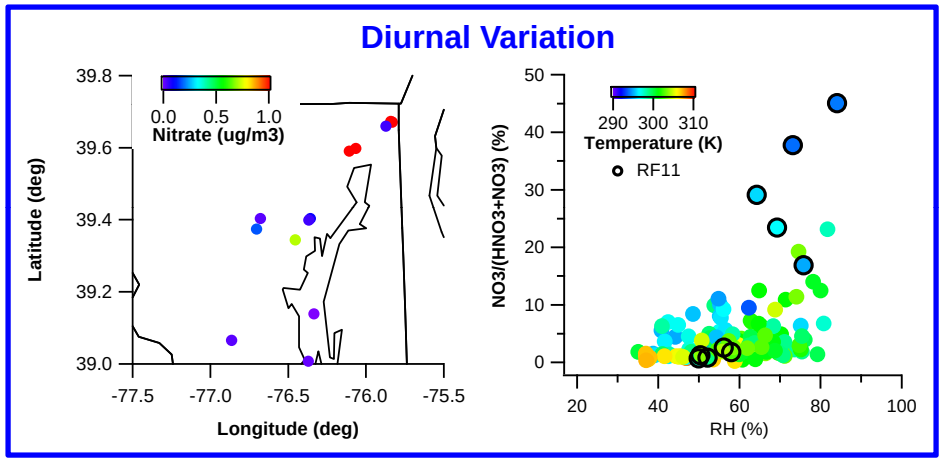


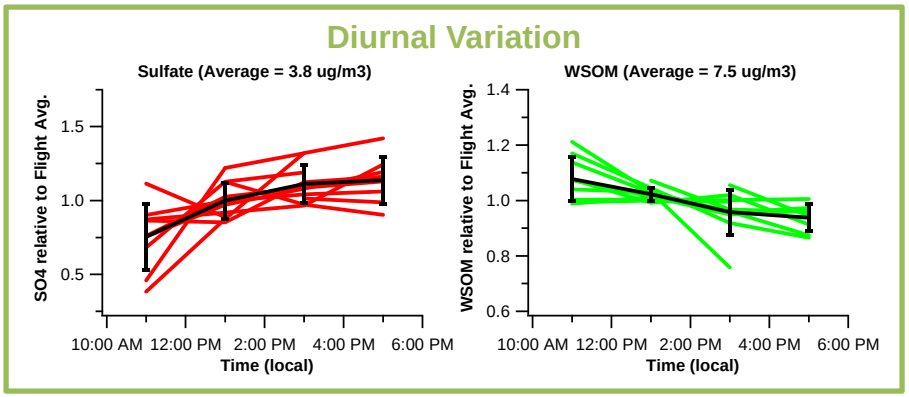


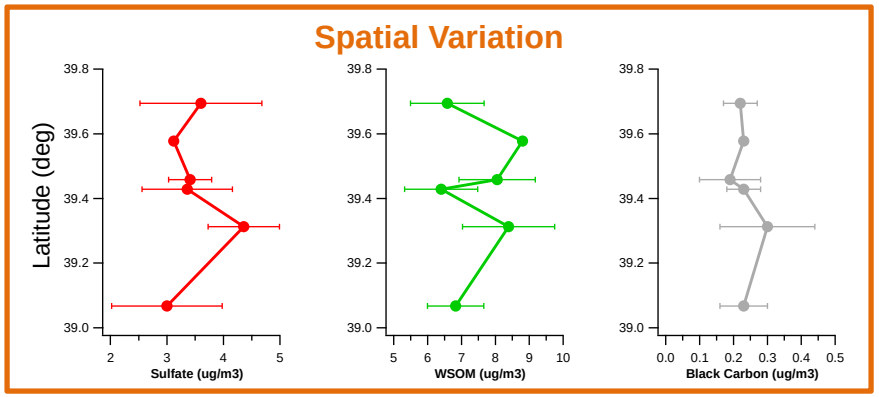
P-3B Aerosol Composition



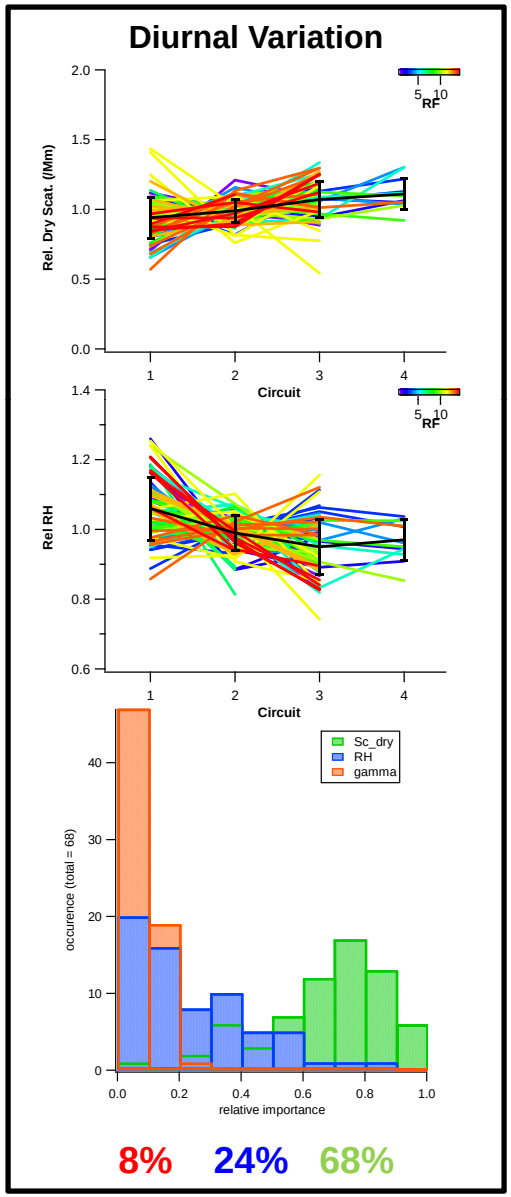
- Nitrate Production: Highest during RF11 due to high HNO_3, high RH and low temperatures







P-3B Aerosol Variability Analysis

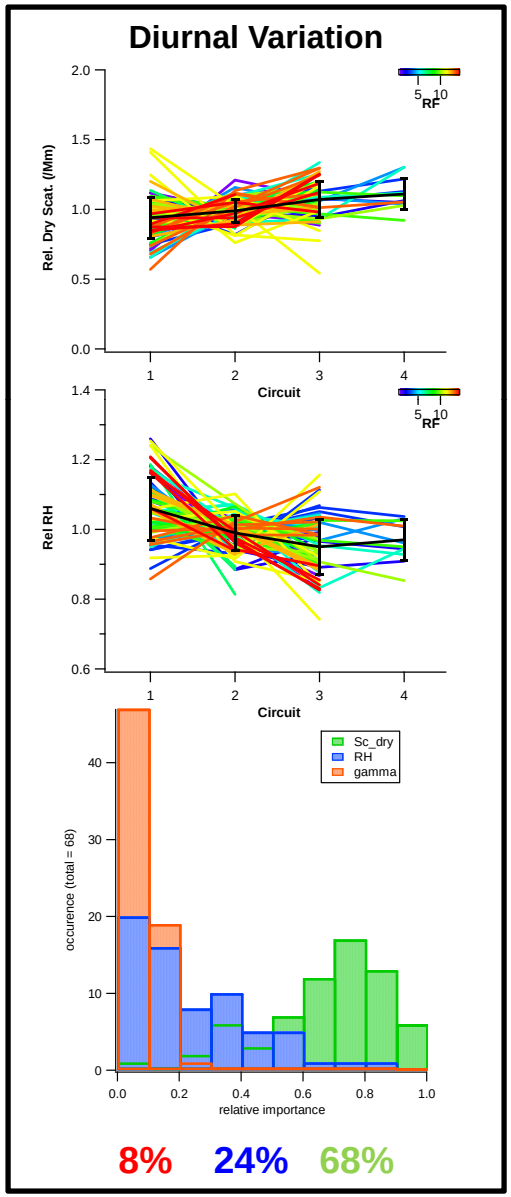


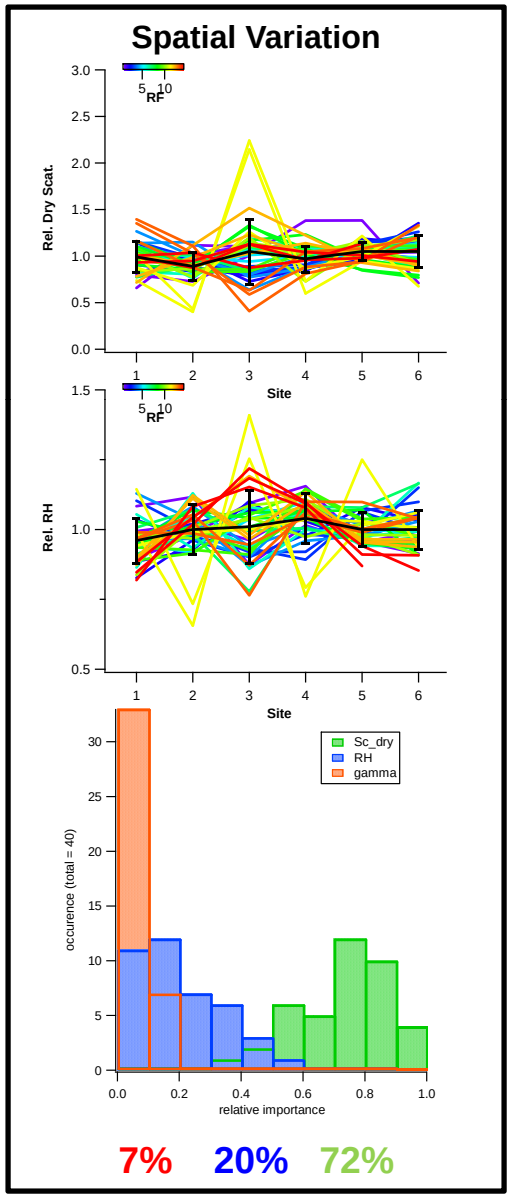
What Factors Have the Greatest Effect on Ambient Aerosol Scattering/AOD?

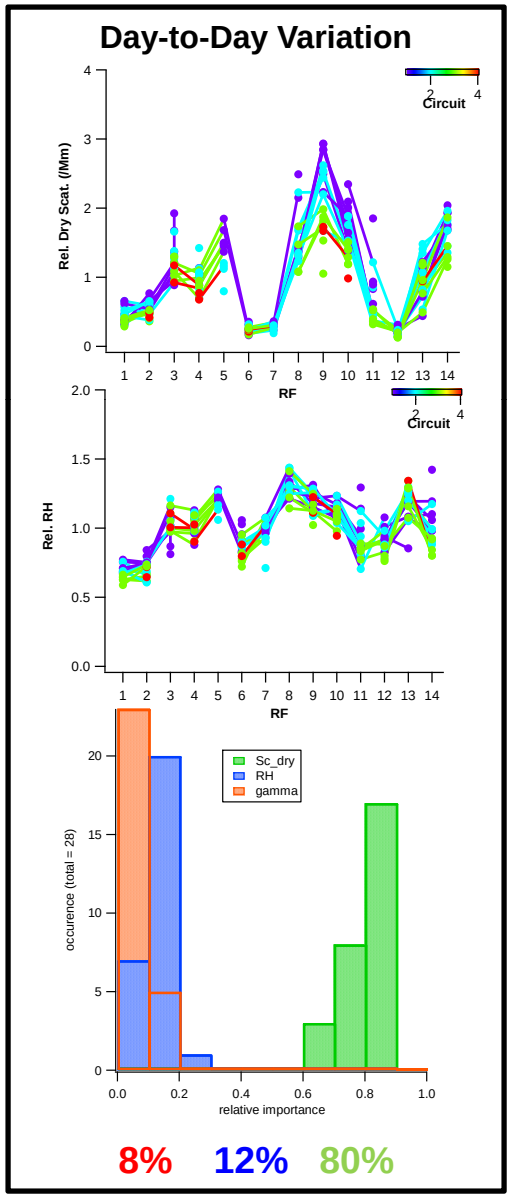
- Determined relative importance of aeorsol loading, RH and composition on variability in ambient scattering/AOD

- Diurnal Variation
  - Aerosol loading (dry scattering) increased during the day while RH decreased
  - This increase in loading accounted for (on average) 68% of the ambient scattering variability throughout the day
  - RH Variability accounted for 24%
  - Variability in aerosol composition resulted in just 8%
- Similar analysis performed for regional and day-to-day variability

P-3B Aerosol Variability Analysis



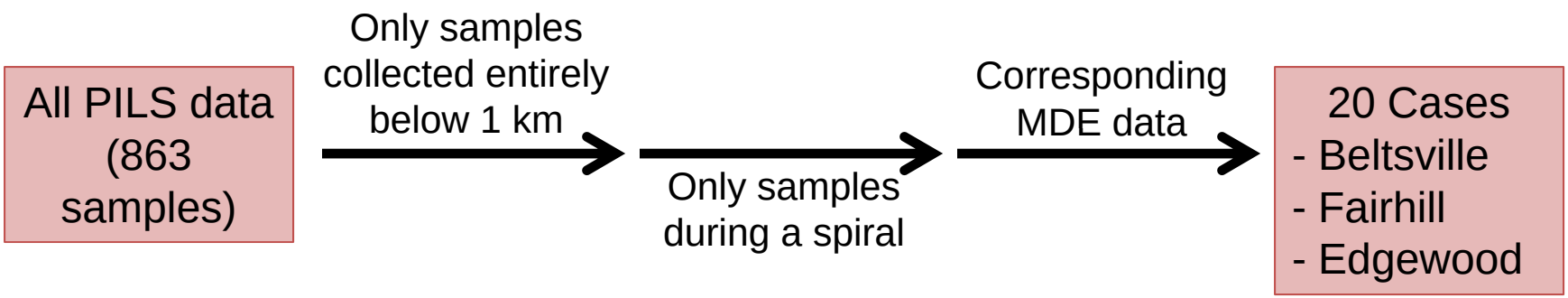




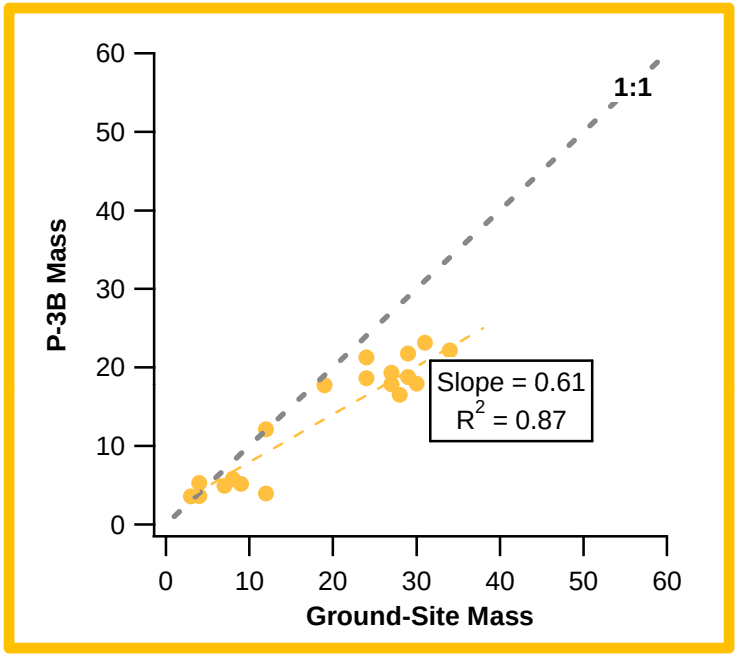
P-3B vs. Ground-Site MDE Aerosol Mass

Aerosol mass measured by

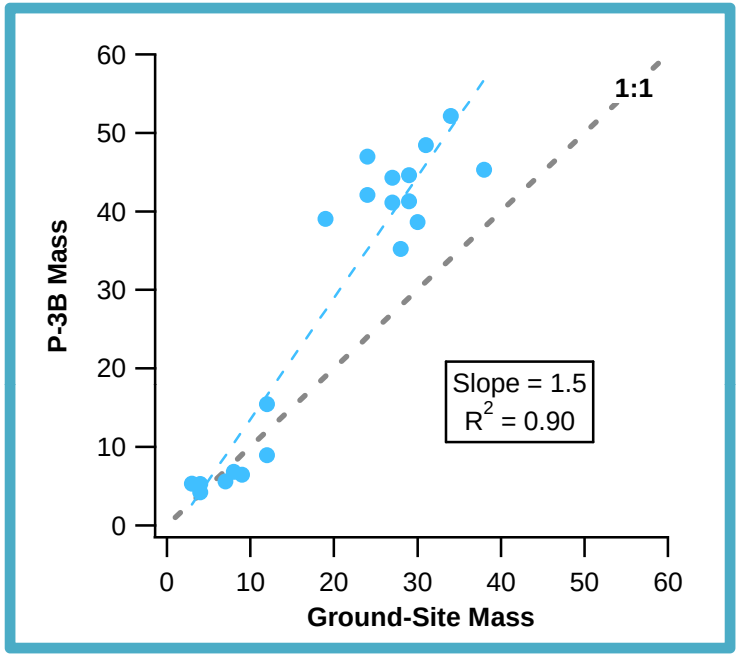
- P-3B: PILS and SP2
  - includes a correction factor for converting WSOC to WSOM
  - does not measure insoluble organics (WISOM)
  - dry aerosol mass
- MDE: Beta-Attenuation Mass Monitor
  - total dry aerosol mass



P-3B vs. Ground-Site MDE Aerosol Mass



Using PILS mass



Correcting for WISOM

- WISOM is calculated from excess scattering:

$$MSE_{inorganic} = 2.6\ m^2/g$$

$$MSE_{WSOC} = 3.9\ m^2/g$$

- Average MSE = 3.5 ± 0.2 m^2/g
- Average Density = 2.9 ± 0.5 g/cm^3

How to prove our retrieval abilities for gases when particles modify the radiation field ?

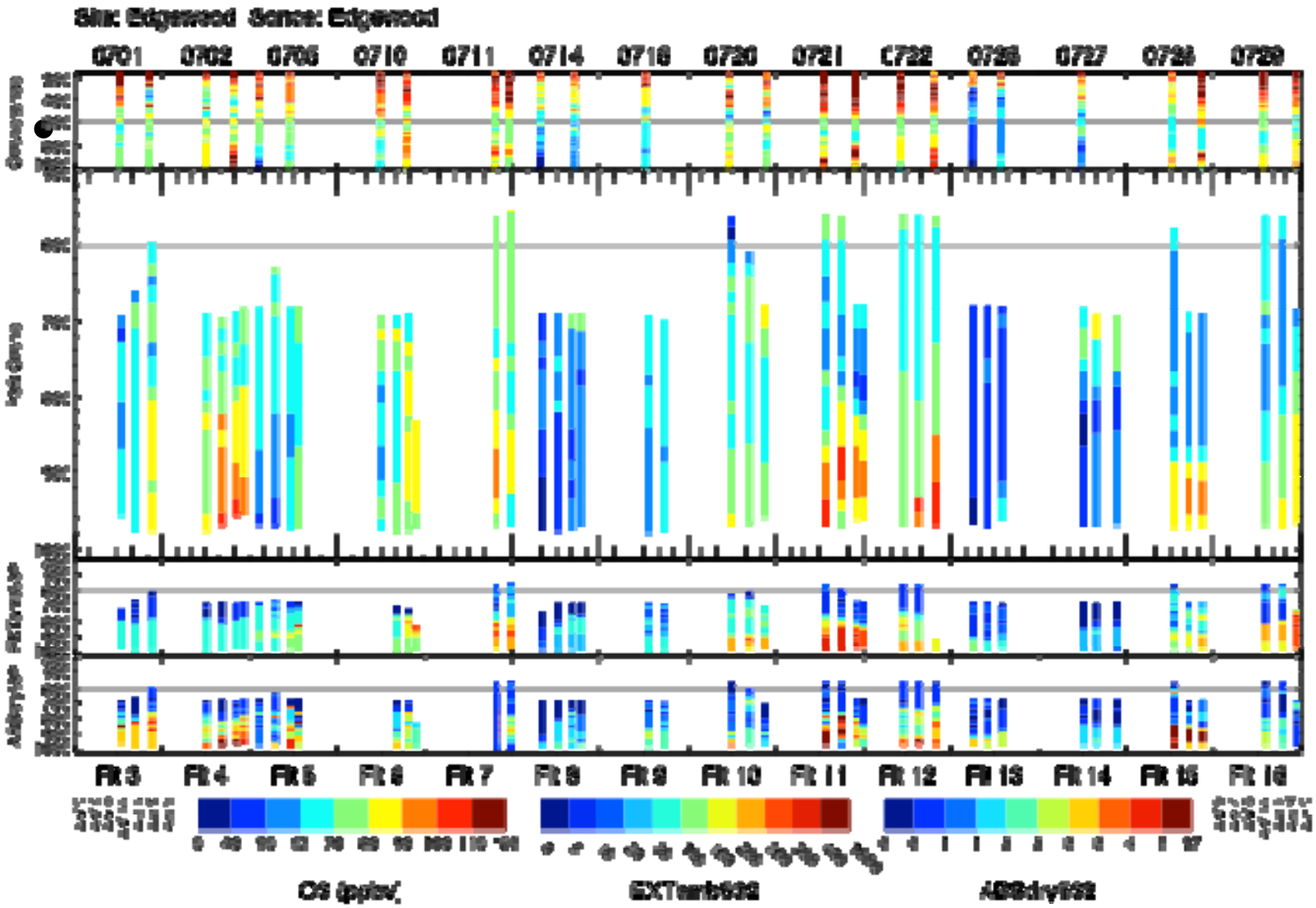
An example of plots for choice

– O_3 profiles, clean and dirty,

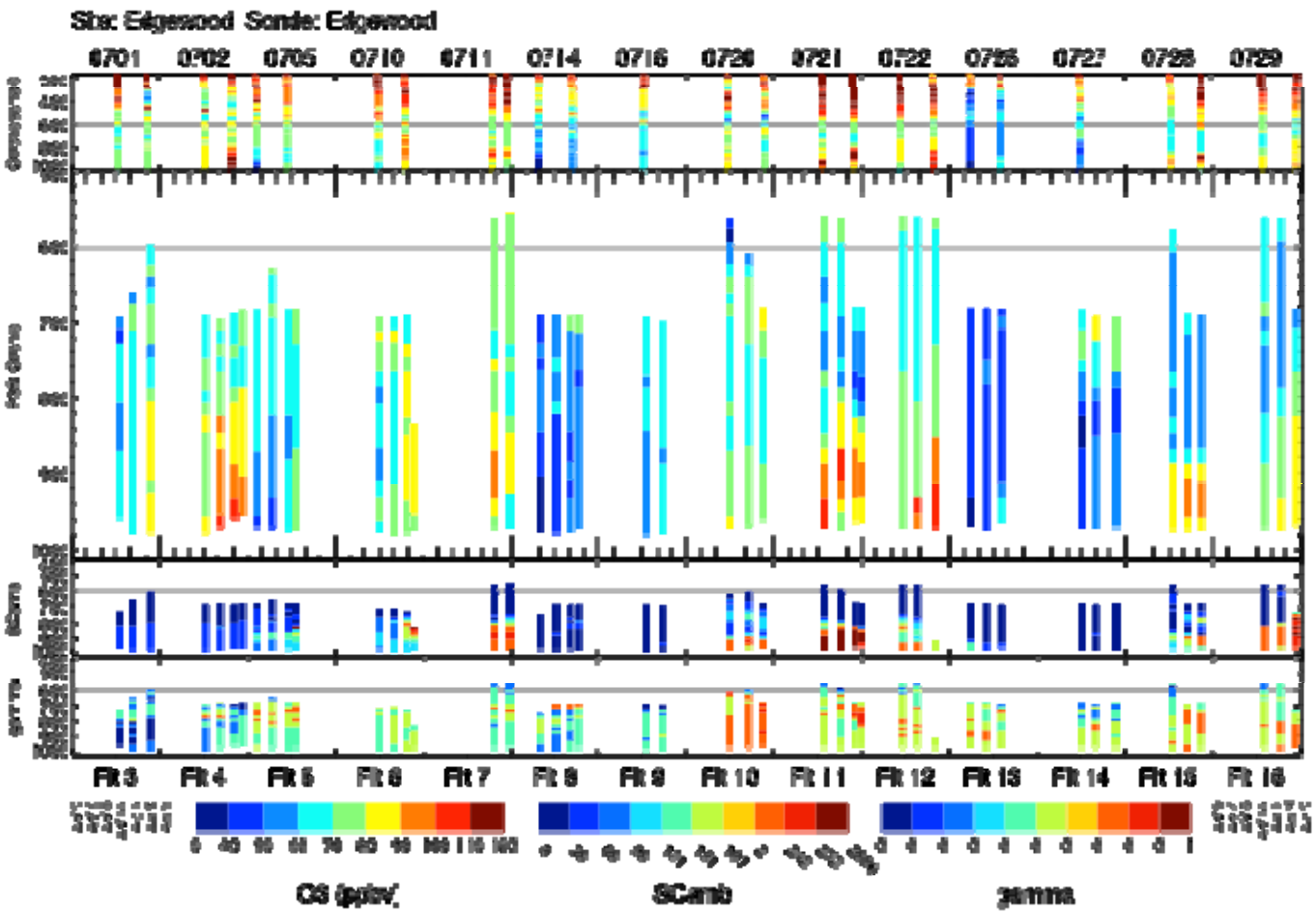
– aerosol profiles, clean,

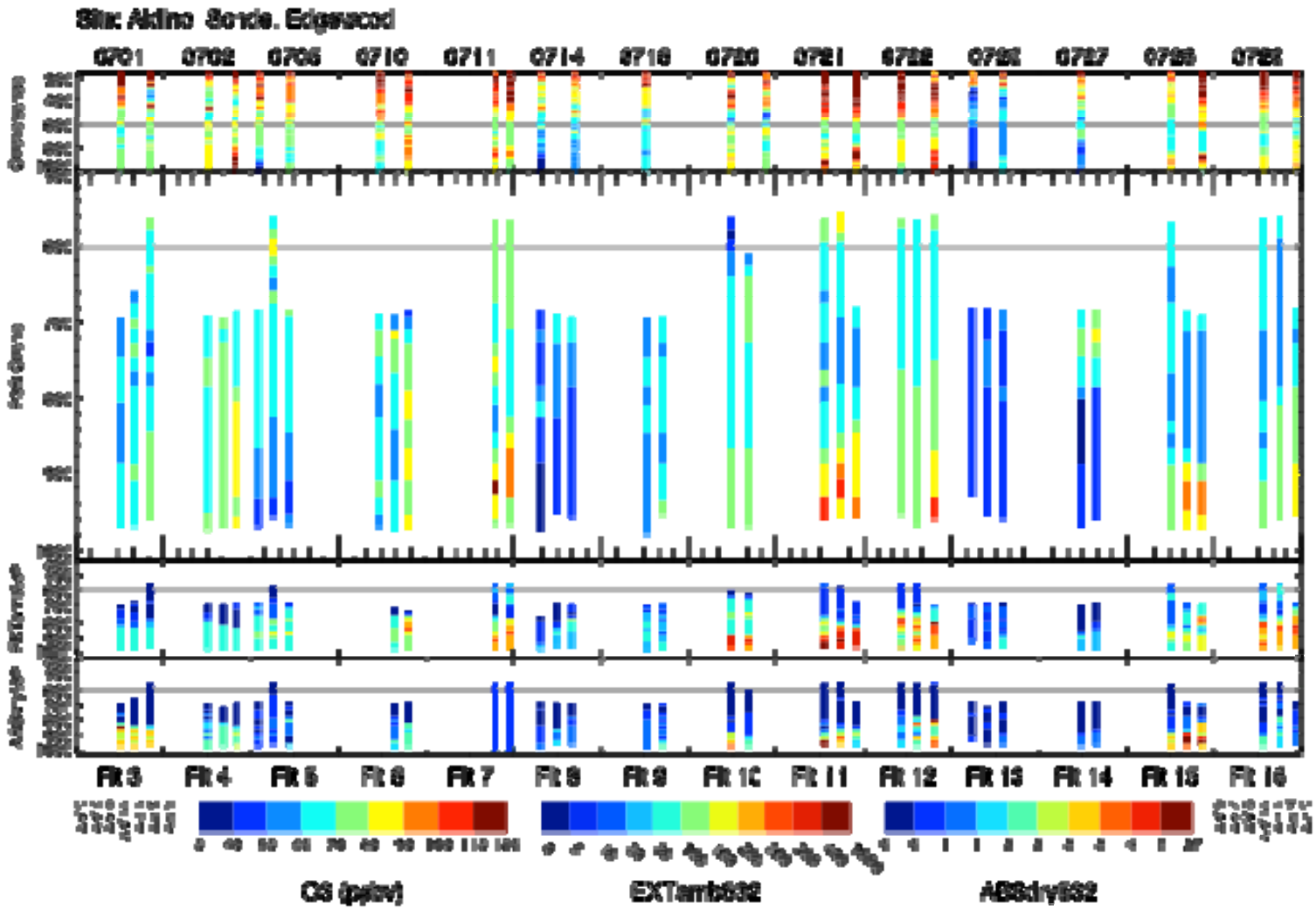
“dirty” – i.e., scattering, or somewhat absorbing

There was variation in scattering and some variation in absorbing particles in D-AQ measurements

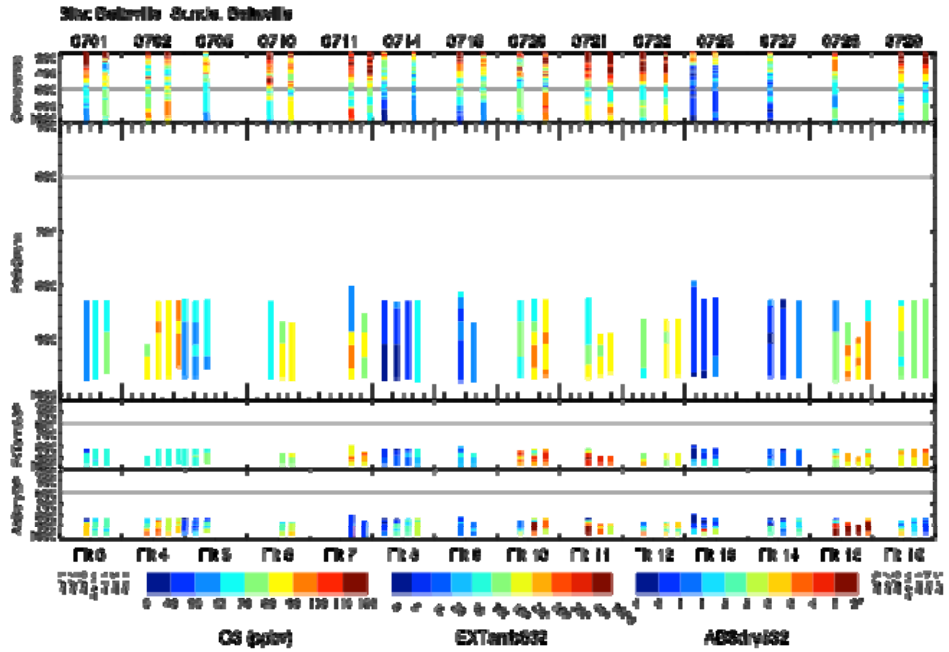


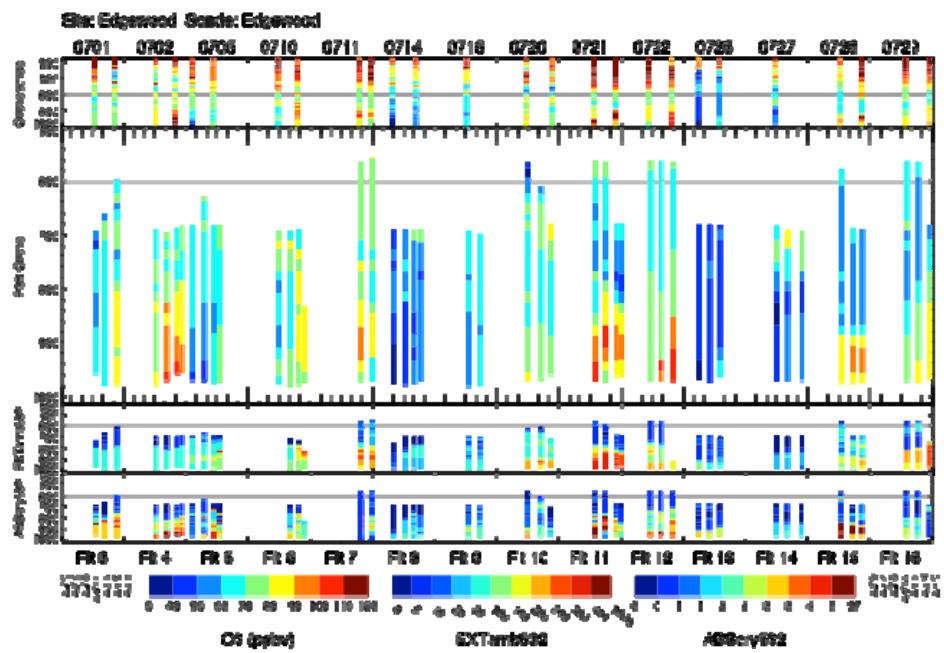
There was also a large variation in hygroscopicity in D-AQ measurements



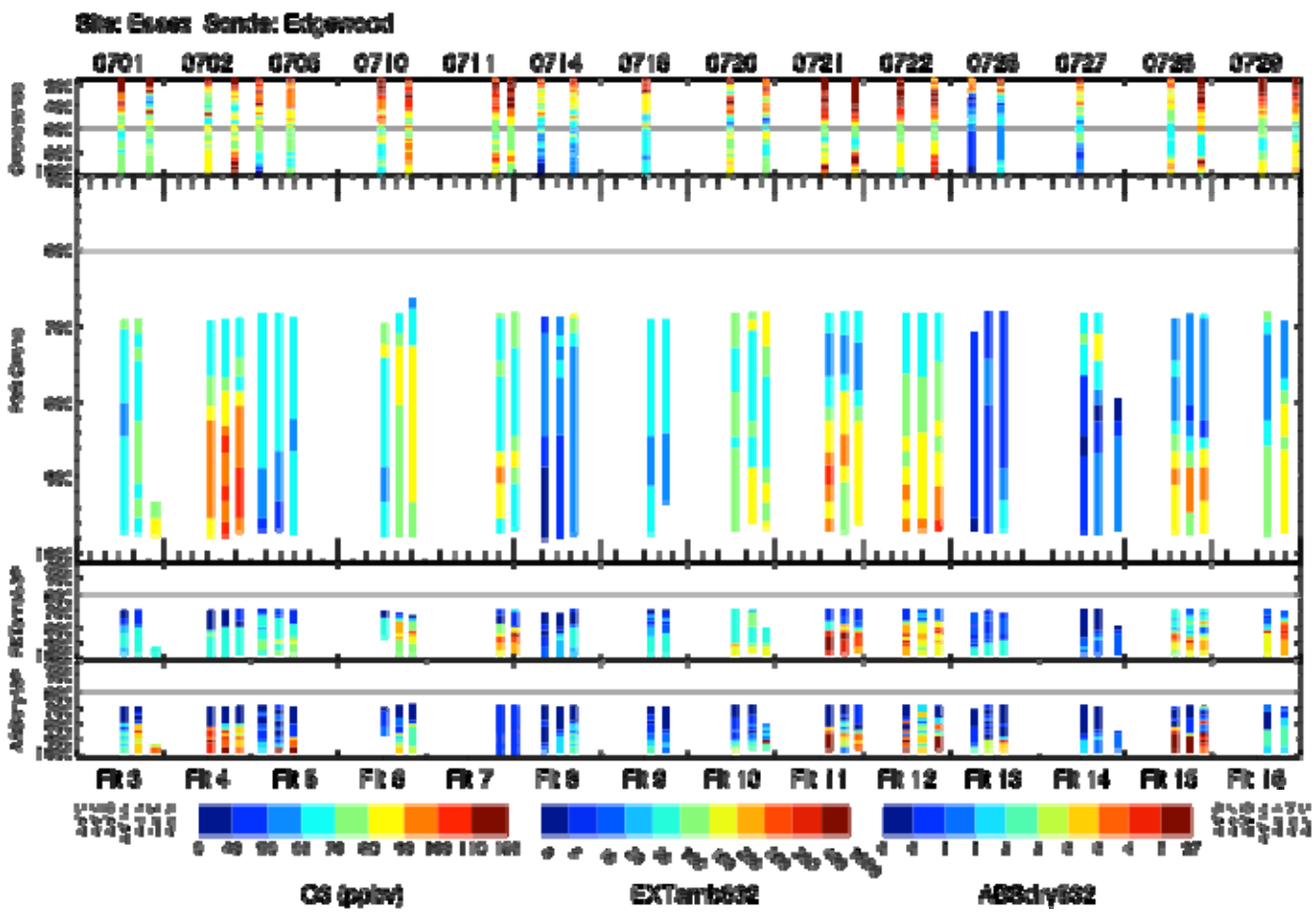

Fr 3
Fr 4
Fr 5
Fr 6
Fr 7
Fr 8
Fr 9
Fr 10
Fr 11
Fr 12
Fr 13
Fr 14
Fr 15
Fr 16
CS (ppbv)
EXTamb532
ABSdry532

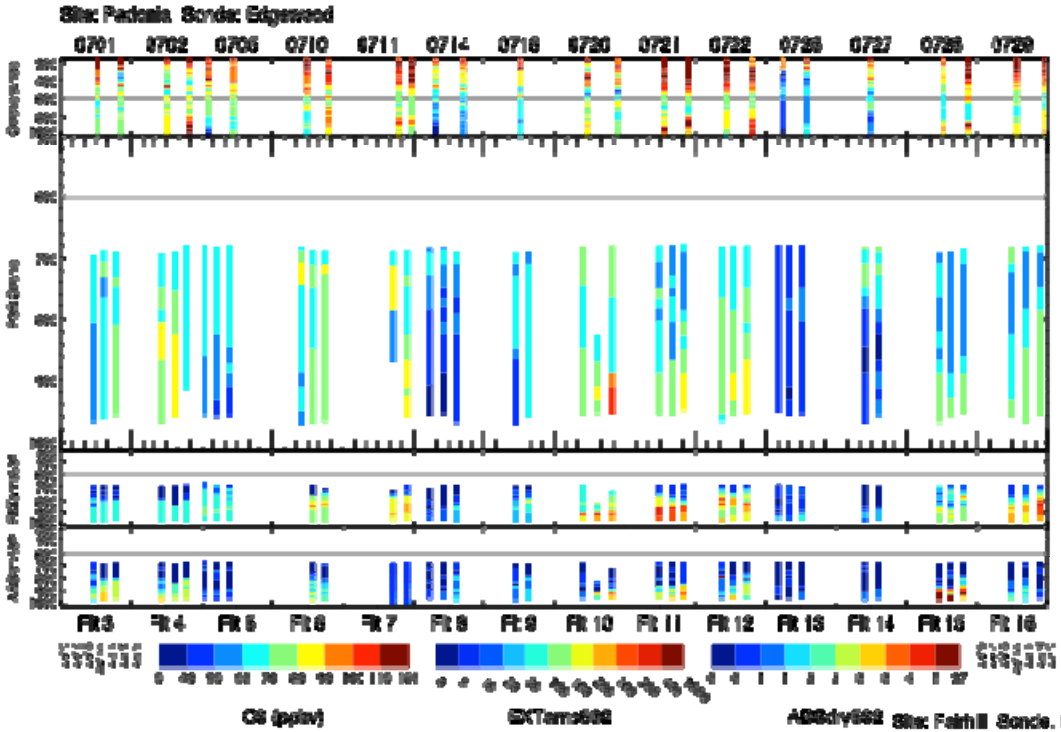
Sondes show much less O_3 variation above P-3 altitude





Essex also has good O_3 pollution samples




Site: Padonia Sonde: Edgewood
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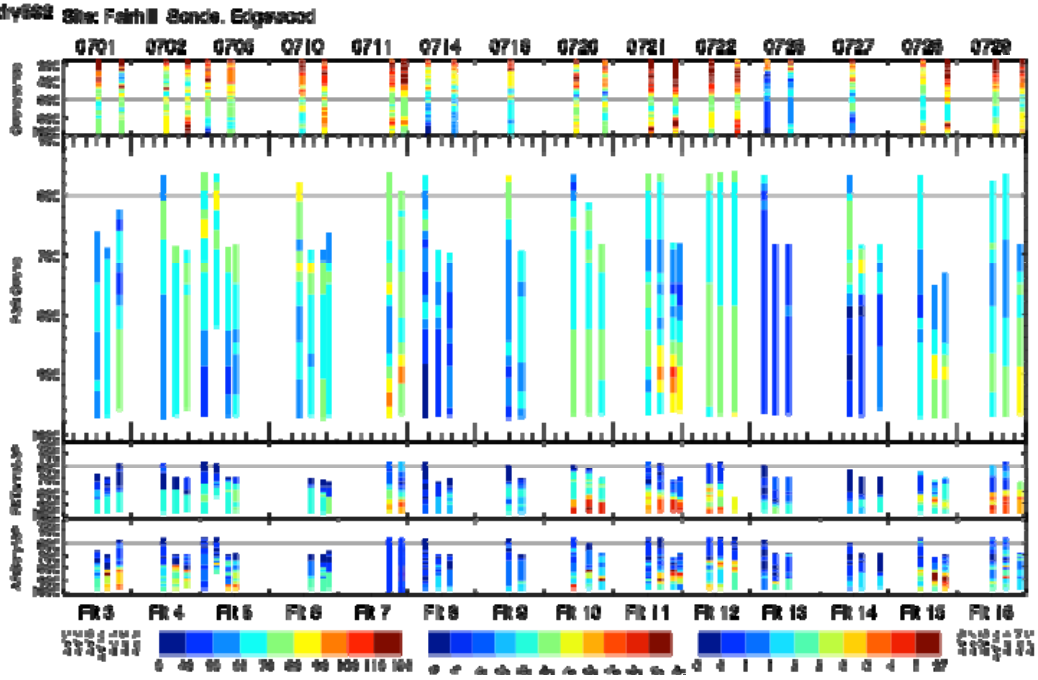
CO (ppbv)


Site: Fairhill Sonde: Edgewood
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Interpreting Lidar Measurements to Better Estimate Surface $PM_{2.5}$ from Columnar Measurements During DISCOVER-AQ 2011

Allen Chu
JCET UMBC/NASA GSFC

DISCOVER-AQ Workshop
February 14-16, 2012
Hampton, VA

List of Important Variables

AOD: Aerosol optical depth

PBL: Planetary Boundary Layer

PBLH: PBL Height

HLH: Haze Layer Height (=PBLH + scale height)

MPE: Mean PBL Extinction (= AOD_{PBL}/PBLH)

NSE: Near-surface Extinction (extinction at lowest altitude possibly detected)

Data Sources & Data Types Used for Analysis

AERONET: AOD

AQS: $PM_{2.5}$

HSRL: AOD, PBLH, extinction profile

MODIS: AOD

MPLNet (GSFC): PBLH, extinction profile

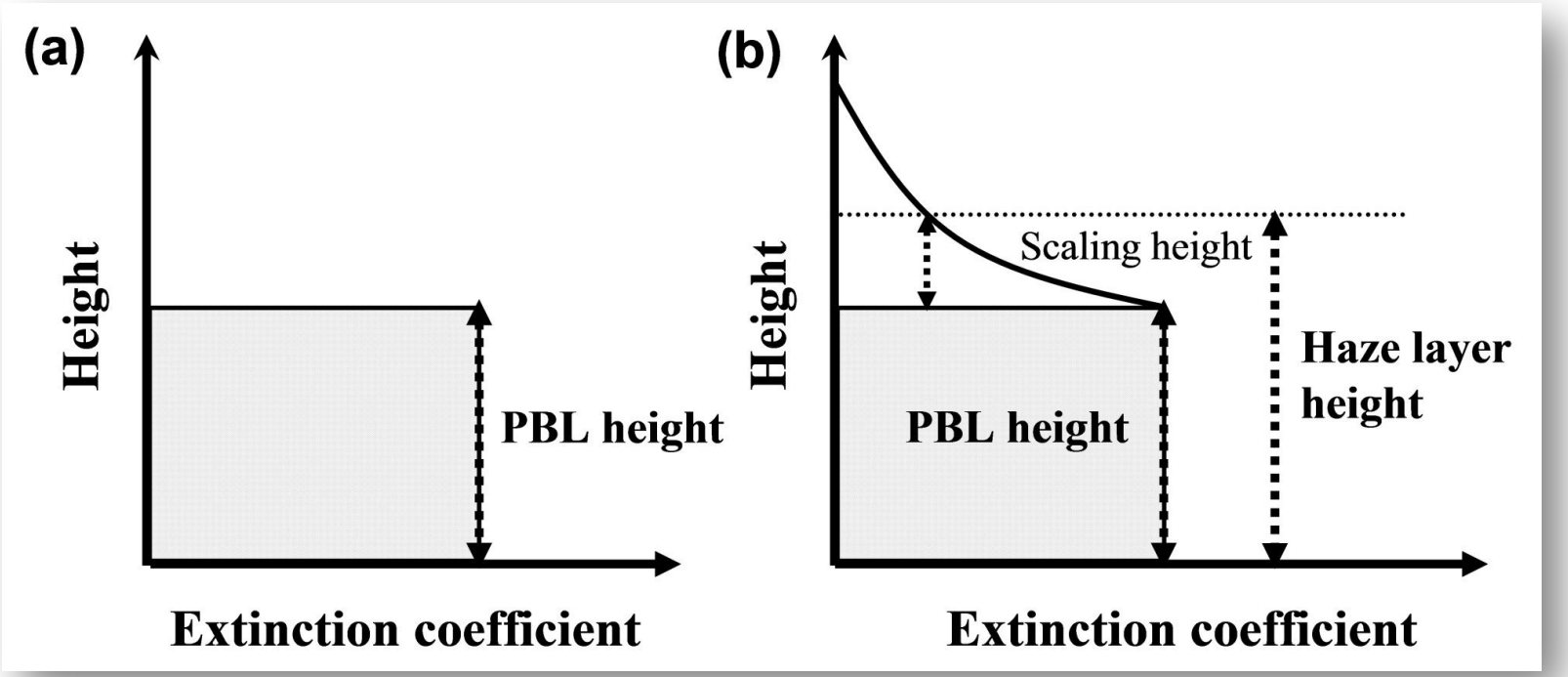
[Need new version of cloud-screened MPL data at MDE sites]

Surface Met Data: W_s, P_s, T_s, RH

Contents

I. Approximation equations of AOD to $PM_{2.5}$
II. HSRL results over San Joaquin Valley in February 14-17 2007
III. Seasonal MPLNet (GSFC) Results of 2007-2010
IV. HSRL results over Baltimore-Washington of July 2011
V. Spatio-temporal analysis of airborne and ground AOD in correlating with hourly surface $PM_{2.5}$

Model of Approximation



$$\int_{PBLH}^{TOA} \upsilon_{0.55\mu m}^{PBLH} e^{-\frac{z-PBLH}{H}} dz = \upsilon_{0.55\mu m}^{PBLH} \int_{PBLH}^{TOA} e^{-\frac{z-PBLH}{H}} dz \approx \upsilon_{0.55\mu m}^{PBLH} H \Rightarrow \tau_{a,0.55\mu m} \approx \upsilon_{0.55\mu m}^{PBLH} (PBLH + H) = \upsilon_{0.55\mu m}^{PBLH} HLH$$

PBLH: PBL height; H : Scale height ; HLH: Haze layer height (=PBLH + H)

Approximation Equations

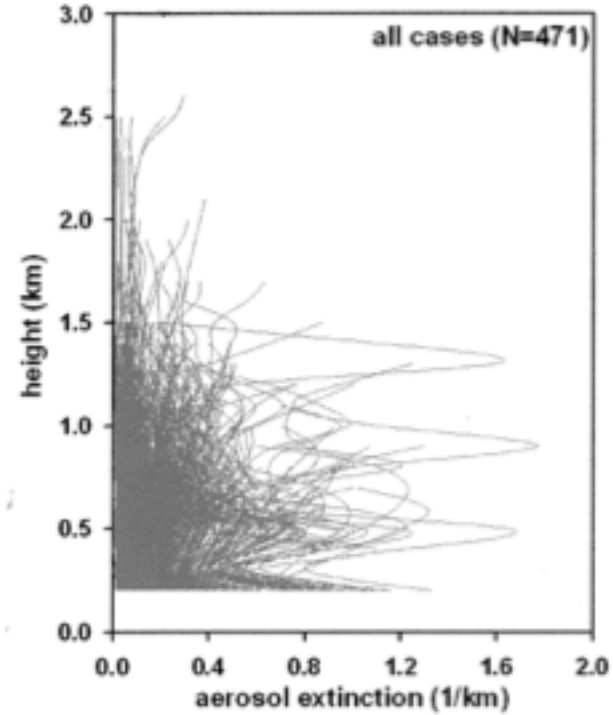
$$\tau_{a,0.55\mu m} = \int_{0}^{TOA} \rho(z)\, \sigma_{0.55\mu m}^{ext}(z)\, dz$$

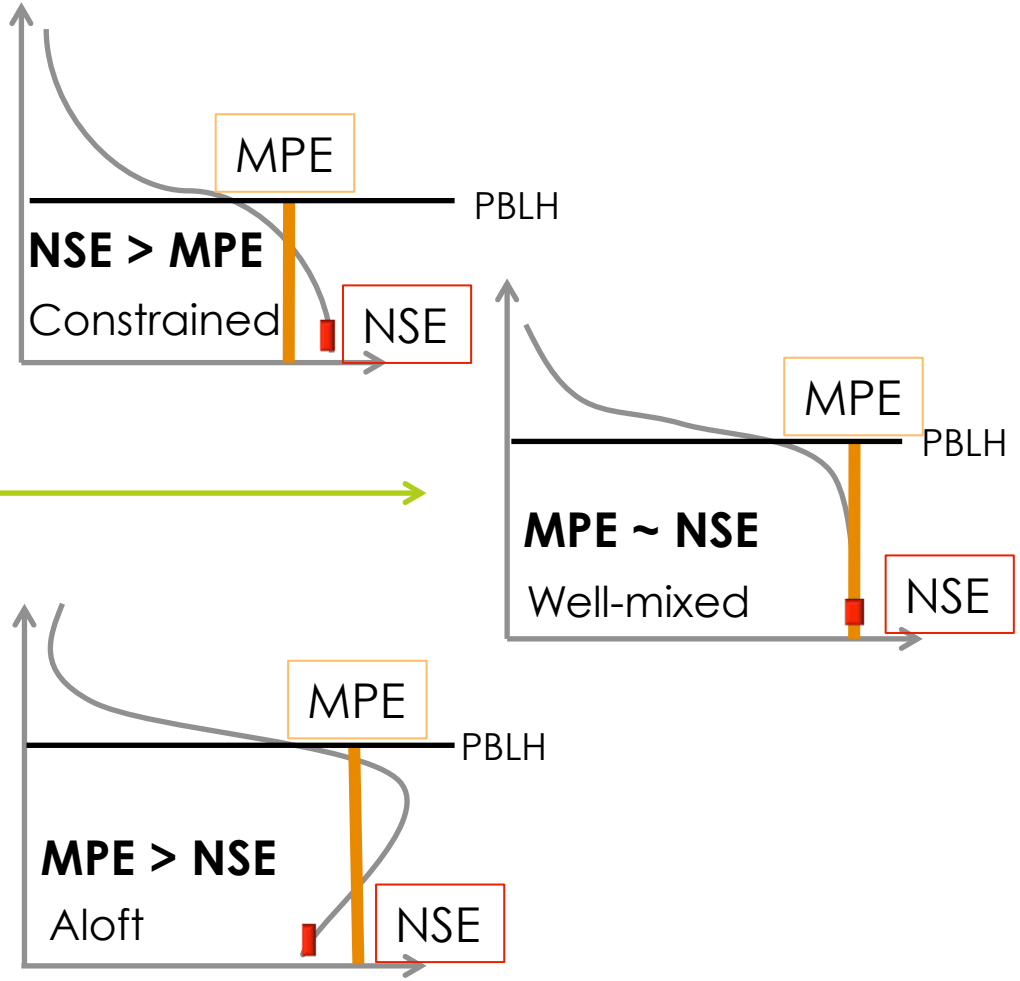
$$\int_{PBLH}^{TOA} \upsilon_{0.55\mu m}^{PBLH} e^{-\frac{z-PBLH}{H}} dz = \upsilon_{0.55\mu m}^{PBLH} \int_{PBLH}^{TOA} e^{-\frac{z-PBLH}{H}} dz \approx \upsilon_{0.55\mu m}^{PBLH} H$$

$$\tau_{a,0.55\mu m} \approx \upsilon_{0.55\mu m}^{PBLH} (PBLH + H) = \upsilon_{0.55\mu m}^{PBLH} HLH$$

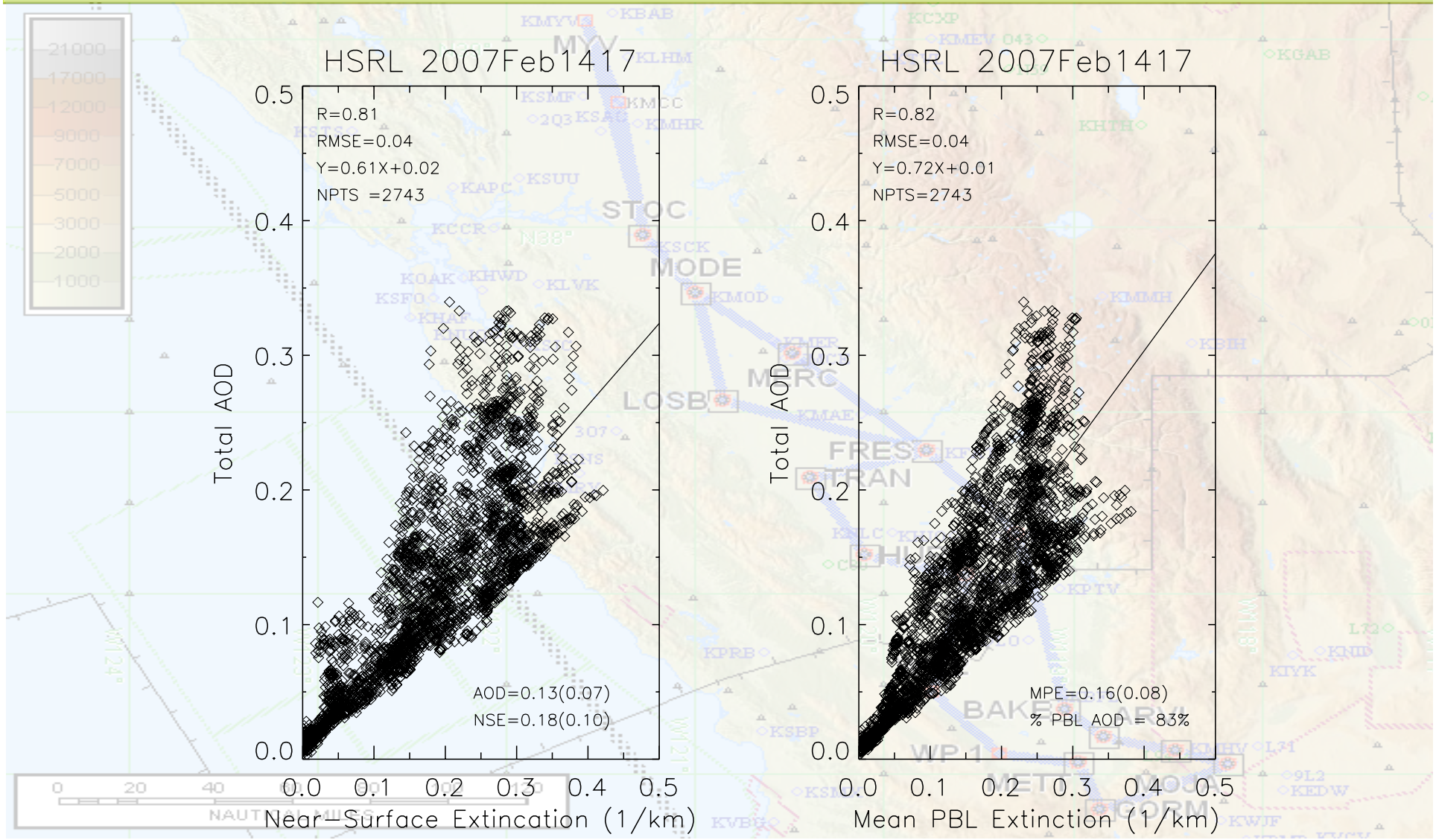
$$PM_{2.5} \approx \frac{\tau_{a,0.55\mu m}}{[f(RH)\sigma_{dry,0.55\mu m}^{ext}]_{surface} L_{mix}}$$

Classification of Extinction Profiles

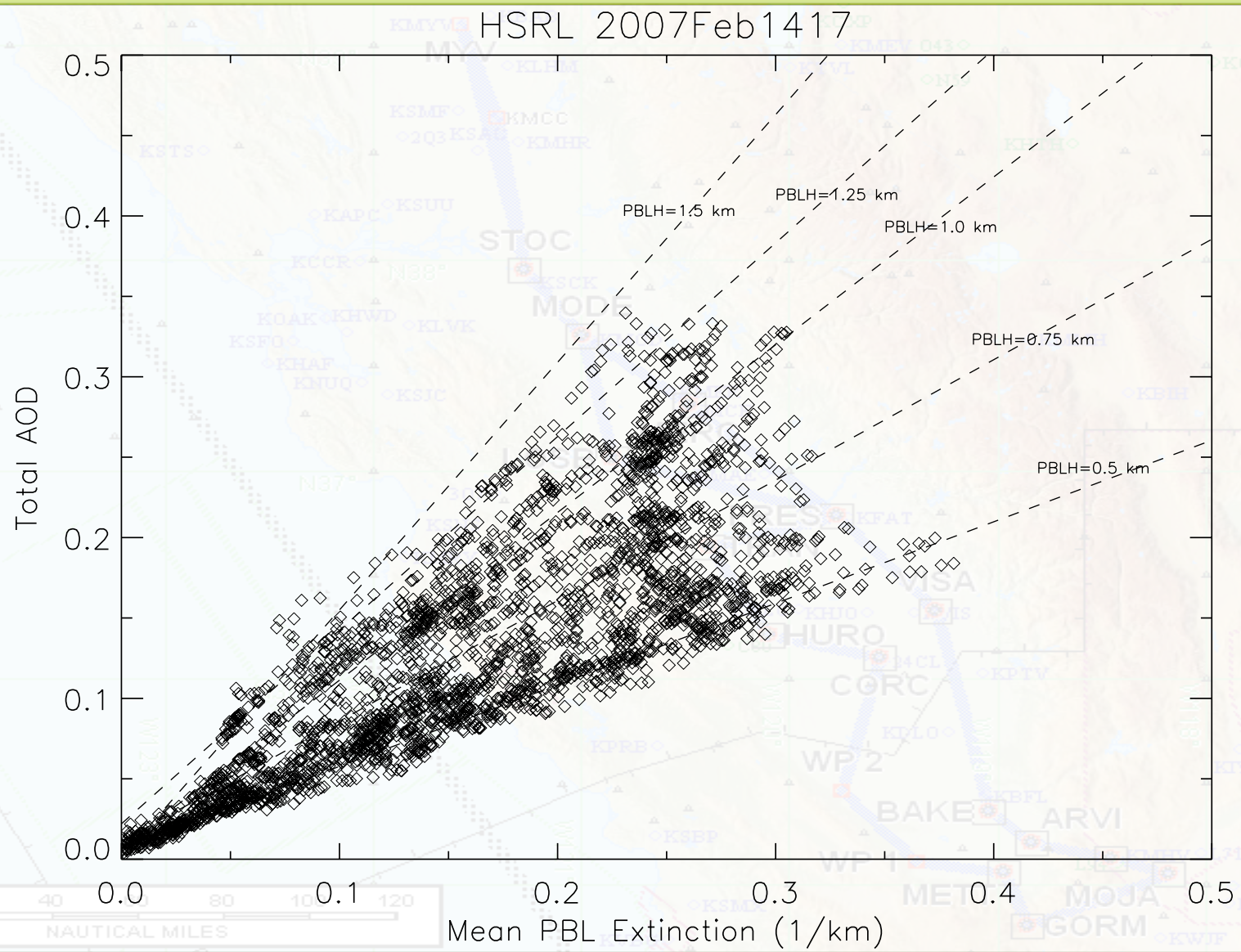




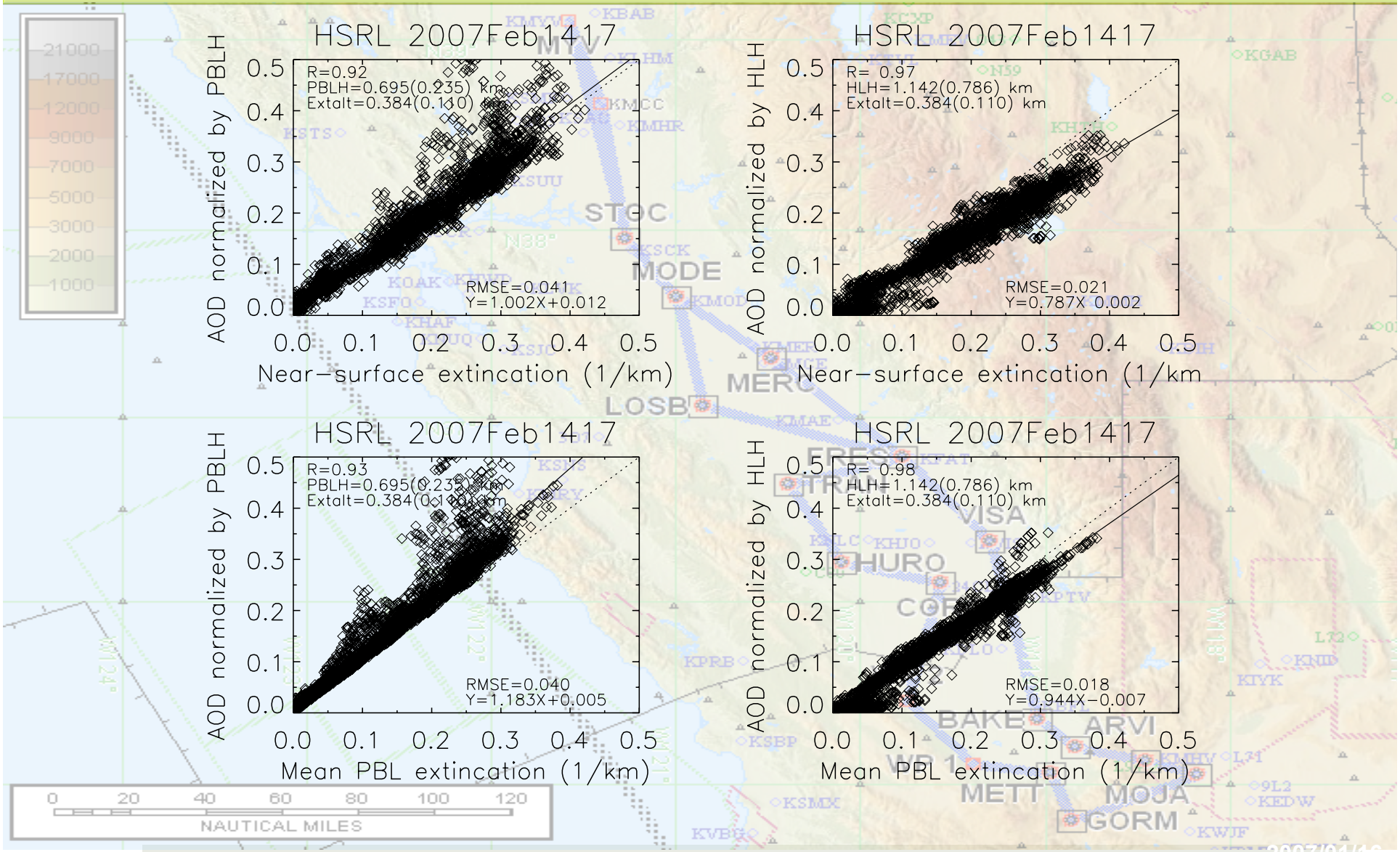
Self-Validation of Approximation Using HSRL NSE and MPE As a Proxy for Surface $PM_{2.5}$



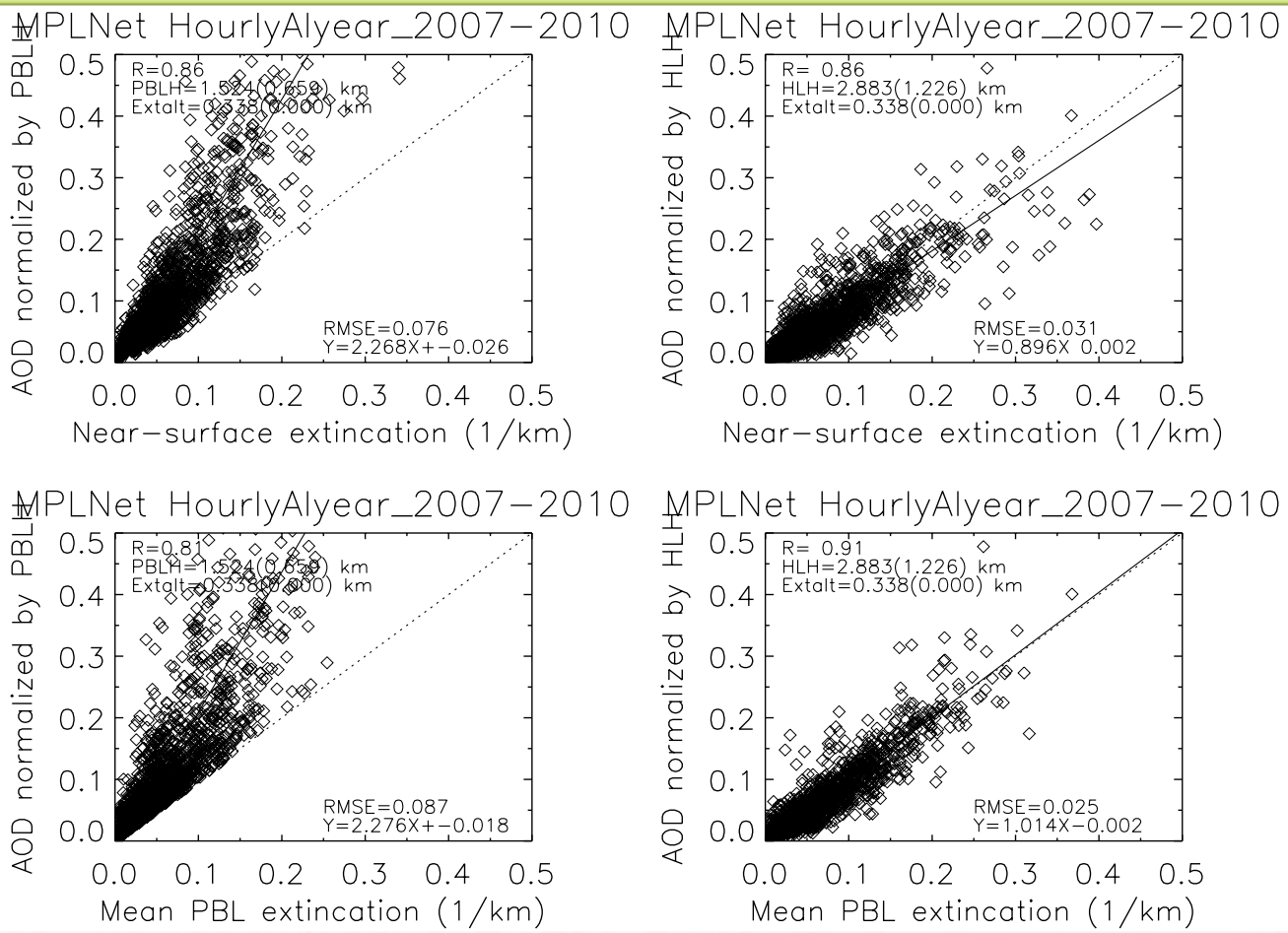
AOD vs. MPL: Strong Function of PBLH (Reversely, AOD_{PBL} /PBLH ~ MPL)



Normalization of AOD by HLH vs. MPE
(Slope ~ 1, Intercept ~0, R: 0.98; RMSE ~0.02)



Normalization of AOD by HLH vs. MPE and NSE
All seasons (2007-2010)



MPE: Slope ~1.0, Intercept ~0.002, R ~0.91 RMSE ~0.025

NSE: Slope ~0.9, Intercept ~0.002, R ~0.86, RMSE ~0.031

Data: MPLNet/AERONET at GSFC

Comparison of Correlation and RMSE Derived By MPLNet at GSFC (2007-2010)

MPE	N	$AOD_{AERONET}$ R/RMSE	$AOD_{AERONET}$/PBLH R/RMSE	$AOD_{AERONET}$/HLH R/RMSE
All Seasons	1828	0.85/0.07	0.81/0.087	0.91/0.025
Autumn	577	0.84/0.06	0.87/0.046	0.93/0.019
Summer	383	0.81/0.10	0.76/0.159	0.90/0.036
Spring	444	0.72/0.06	0.77/0.060	0.83/0.021
Winter	424	0.63/0.03	0.84/0.027	0.80/0.020
(NSE) (Winter)	(424)	(0.65/0.03)	(0.87/0.024)	(0.90/0.014)

- Hourly averaged data

DISCOVER-AQ

Correlation of Temporal Average between MPLNet MPE and $AOD_{AERONET}$/HLH (2007-2010)

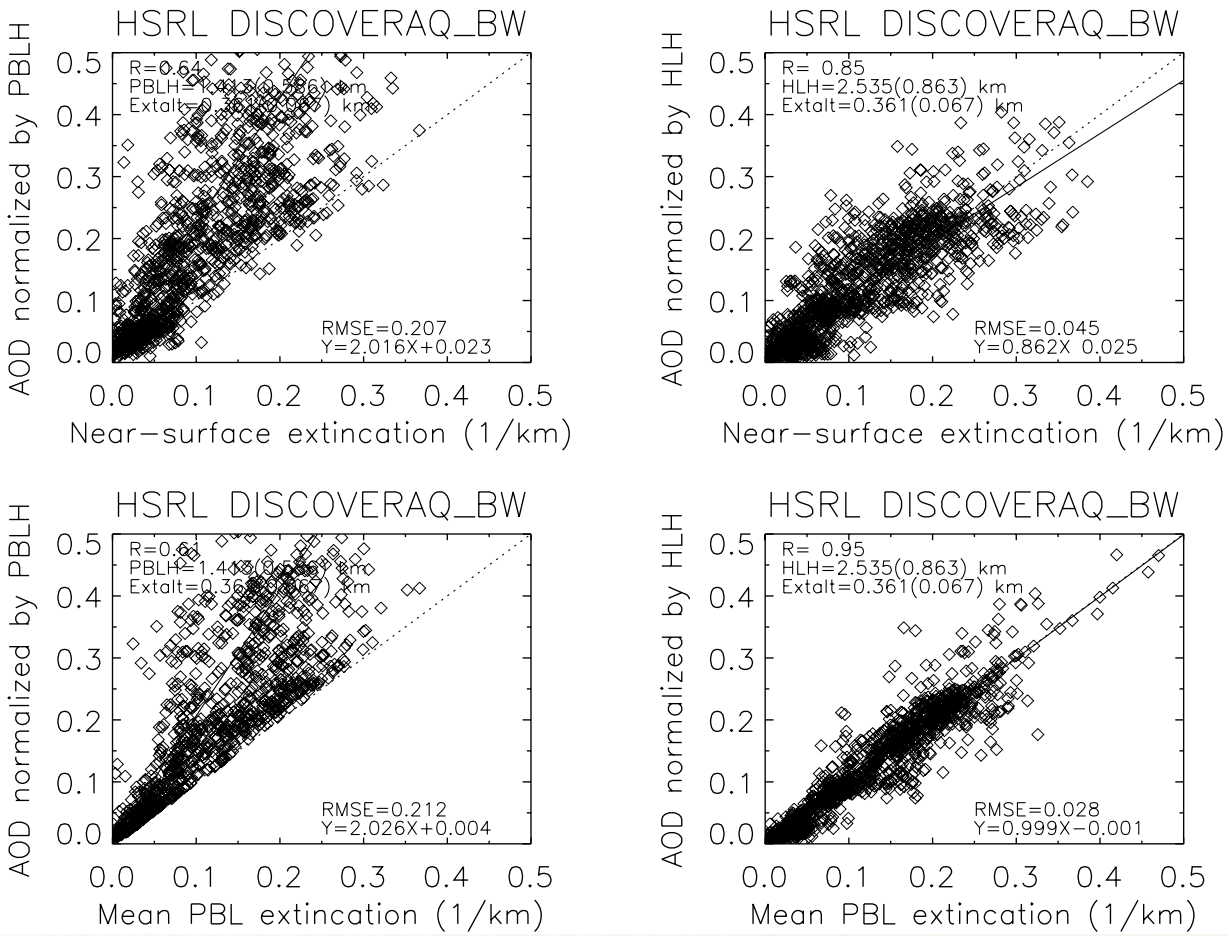
	All data (N=6351)	Hourly Average (N=1828)	AM or PM (3-hour average) (N=819)
All	0.88	0.91	0.91
Autumn	0.90	0.93	0.95
Summer	0.86	0.90	0.87
Spring	0.80	0.83	0.87
Winter (MPE)	0.76	0.80	0.77
Winter (NSE)	0.87	0.90	0.90

MPLNet/ AERONET

$PM_{2.5}$

MODIS AOD

Normalization of AOD by HLH vs. MPE and NSE
Raw HSRL - DISCOVER-AQ (July 2011)



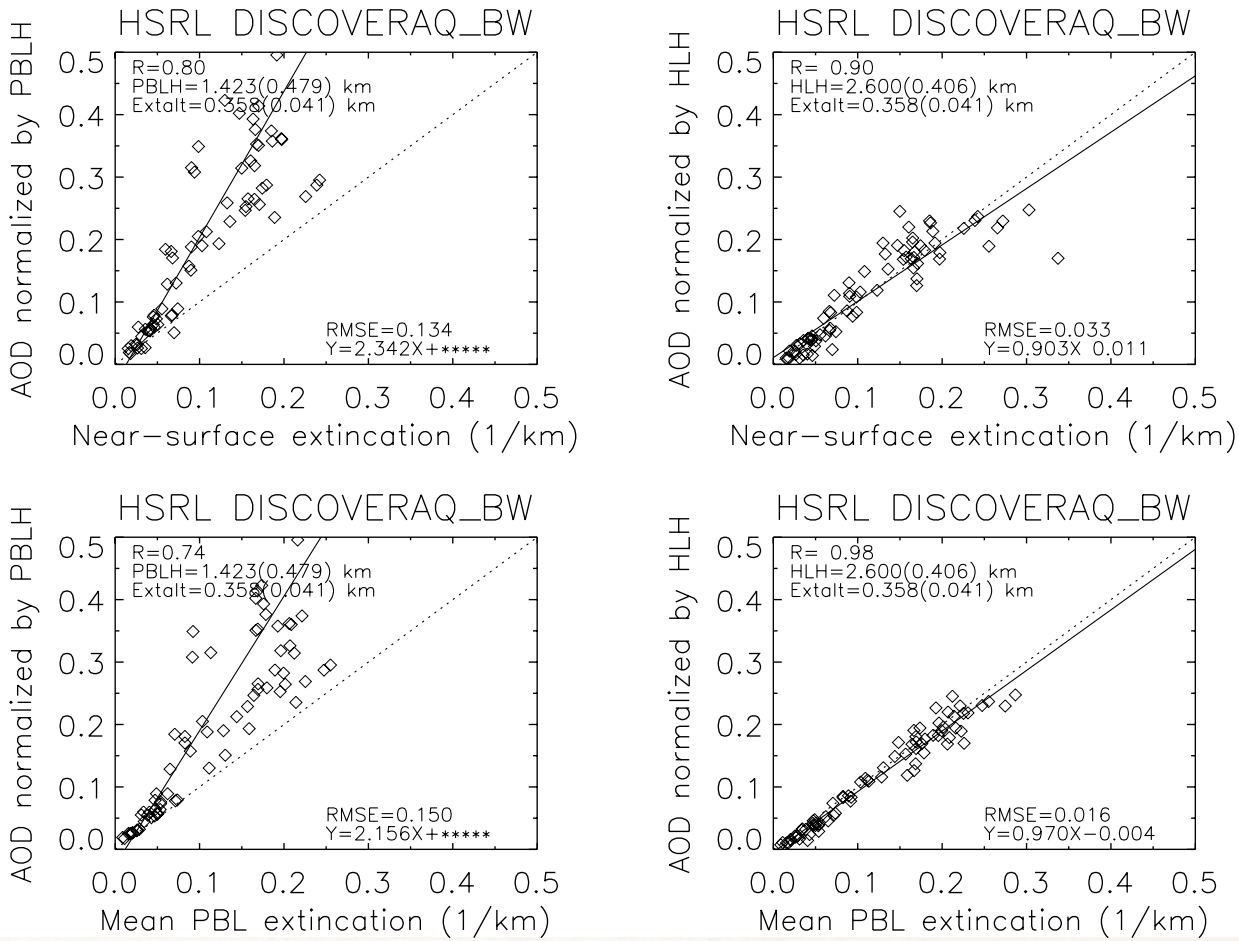
N=1295

MPE: Slope ~1.00, Intercept ~0.001, R ~0.95 RMSE ~0.028

NSE: Slope ~0.86, Intercept ~0.025, R ~0.85, RMSE ~0.045

DISCOVER-AQ

Normalization of AOD by HLH vs. NSE and MPE Hourly HSRL - DISCOVER-AQ (July 2011)



N=76

MPE: Slope ~0.97, Intercept ~-0.004, R ~0.98 RMSE ~0.016

NSE: Slope ~0.90, Intercept ~0.011, R ~0.90, RMSE ~0.033

Advantages:
Normalizing AOD by HLH

- Same scale of extinction measured by lidar and surface instruments

- Criteria: Slope ~1, intercept ~0, R ~1, RMSE ~0 can be imposed

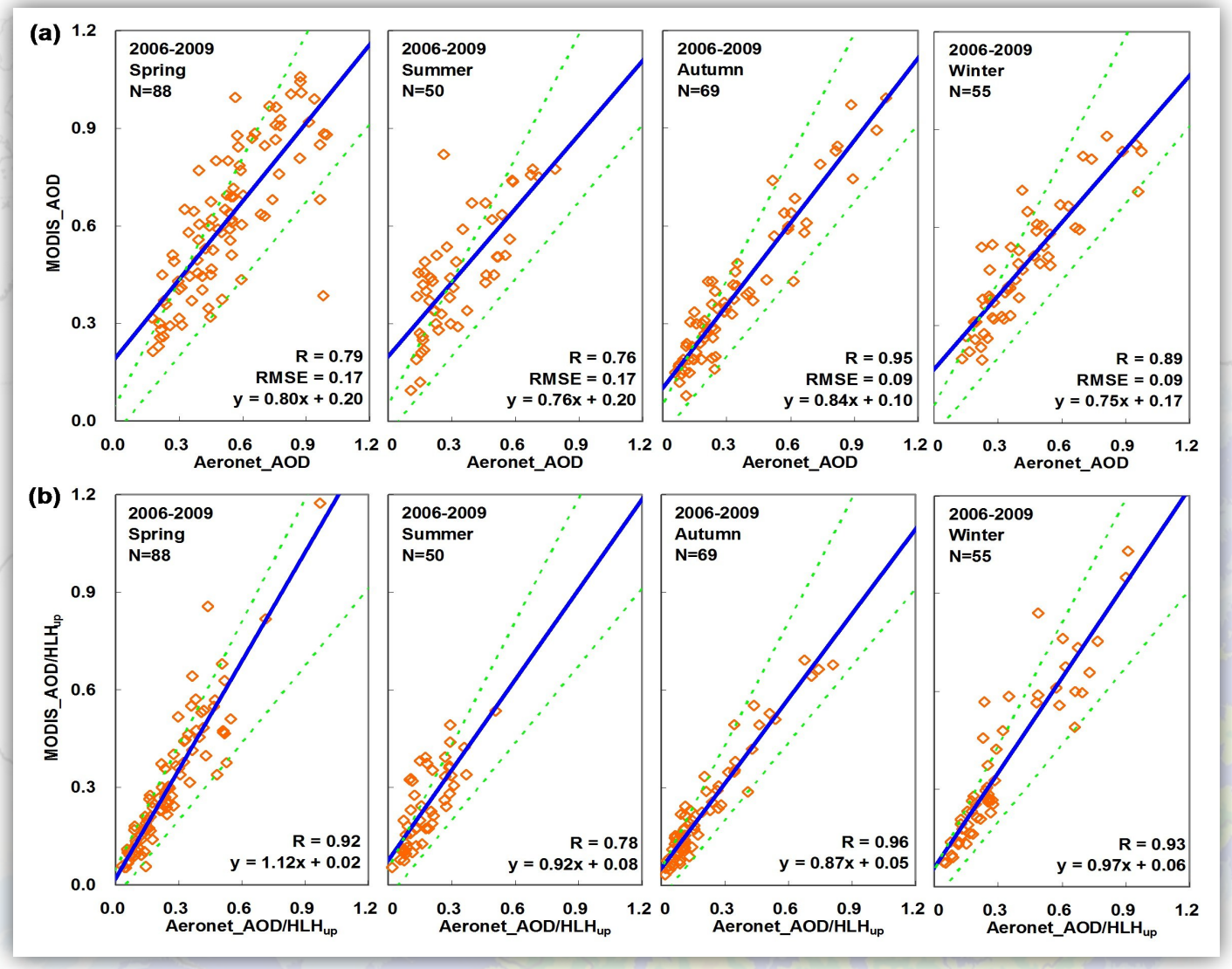
- Better correlation between

  AOD_{MODIS} / HLH and $AOD_{AERONET}$ / HLH

  than

  AOD_{MODIS} and $AOD_{AERONET}$

AOD_{MODIS} / HLH vs. $AOD_{AERONET}$ / HLH
More tolerance to Retrieval of AOD retrieval

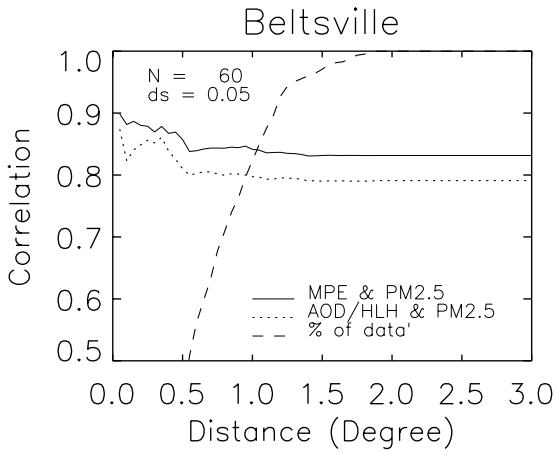


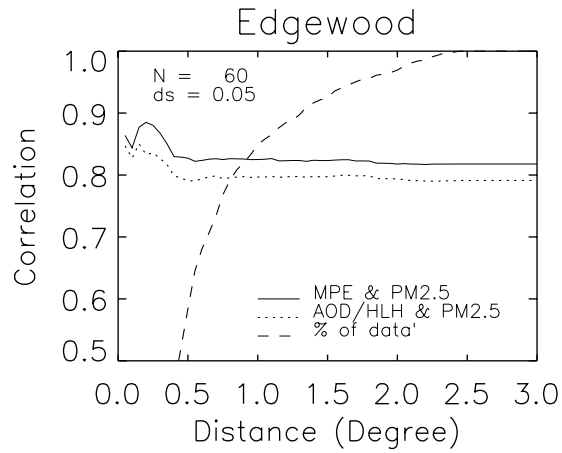
Taiwan study - Chu et al. (2011)

Correlation of Raw HSRL MPE and AOD/HLH with Hourly $PM_{2.5}$ as a Function of Distance

Distance:

B-E: 64 km
B-F: 113 km
B-O: 36 km



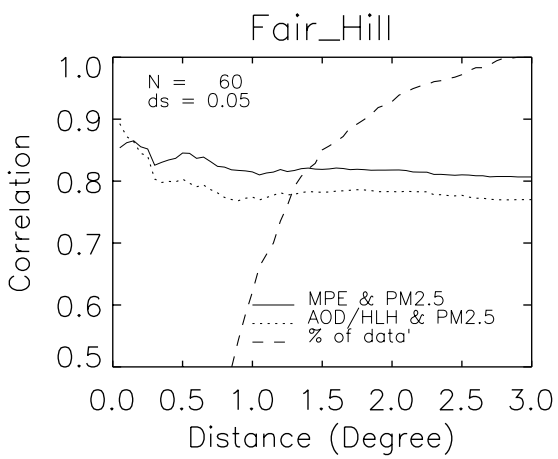


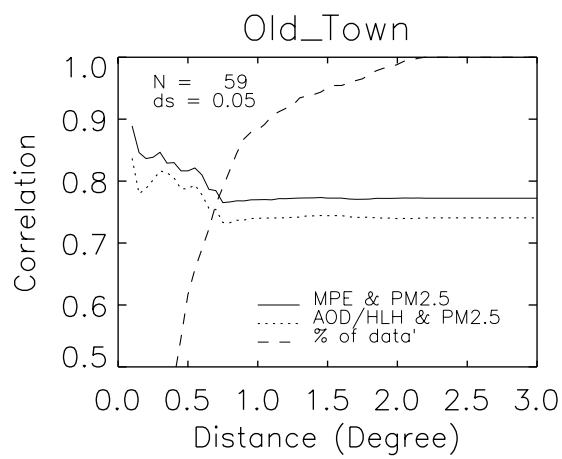
Distance:

E-B: 64 km
E-F: 50 km
E-O: 29 km

Distance:

F-B: 113 km
F-E: 50 km
F-O: 78 km





Distance:

O-B: 64 km
O-E: 29 km
O-F: 78 km

• Multiple (HSRL) to 1 ($PM_{2.5}$) within an hour • All behave similarly in correlation as a function of distance • Missing factor: f(RH)

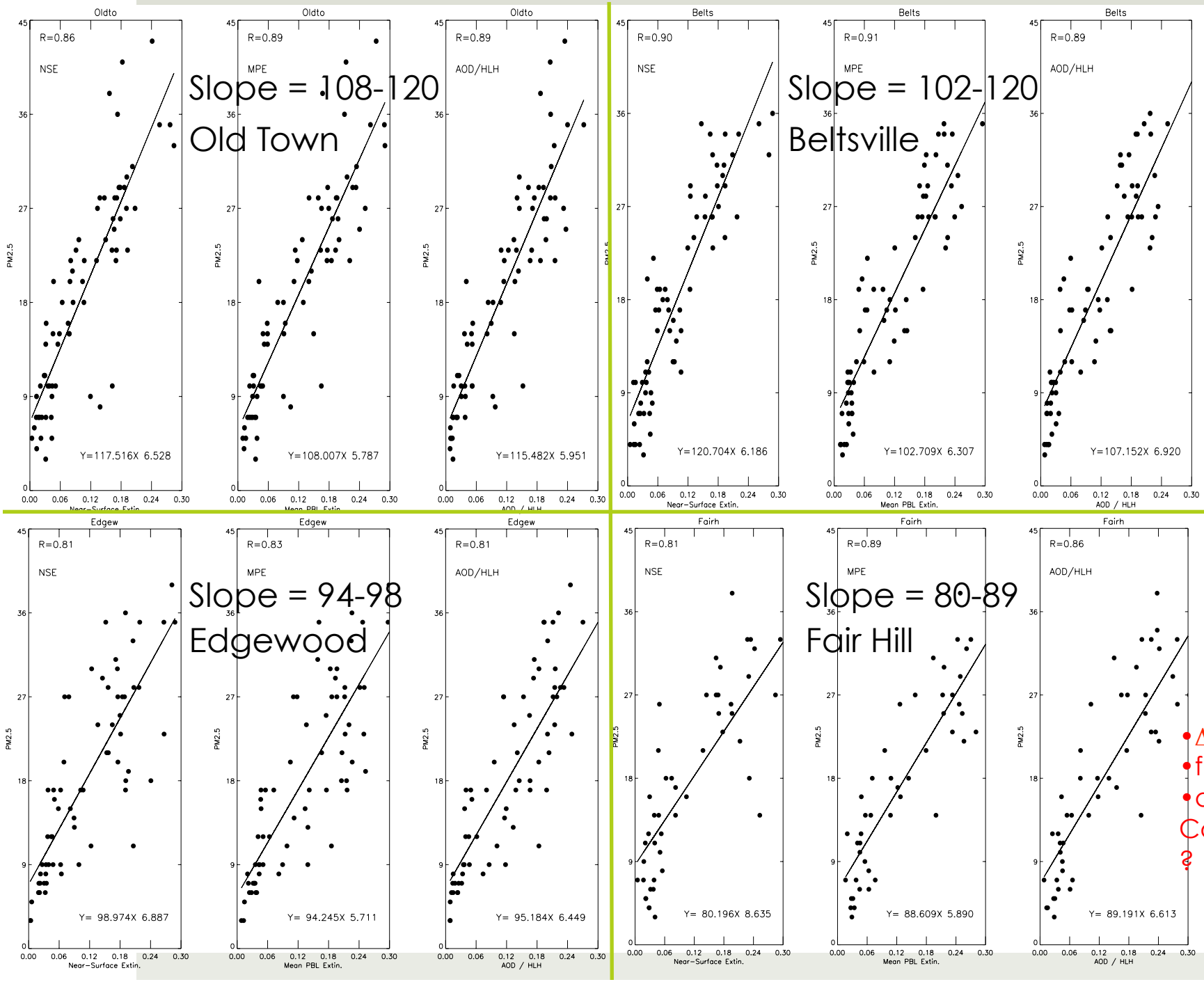
DISCOVER-AQ

Correlation of Spatial Variation between Hourly HSRL MPE & AOD/HLH and Hourly $PM_{2.5}$

	Hourly $PM_{2.5}$ $\Delta S = 0.25°$	Hourly $PM_{2.5}$ $\Delta S = 0.5°$	Hourly $PM_{2.5}$ $\Delta S = 0.75°$
Beltsville	0.89/0.89 (N=48)	0.91/0.89 (N=70)	0.91/0.89 (N=74)
Edgewood	0.88/0.85 (N=48)	0.83/0.81 (N=67)	0.83/0.82 (N=70)
Fair Hill	0.88/0.86 (N=31)	0.89/0.86 (N=50)	0.88/0.83 (N=61)
Old Town	0.86/0.83 (N=55)	0.89/0.89 (N=71)	0.86/0.83 (N=74)

- 1 (HSRL) to 1 ($PM_{2.5}$) • R slightly decreases with distance

DISCOVER-AQ



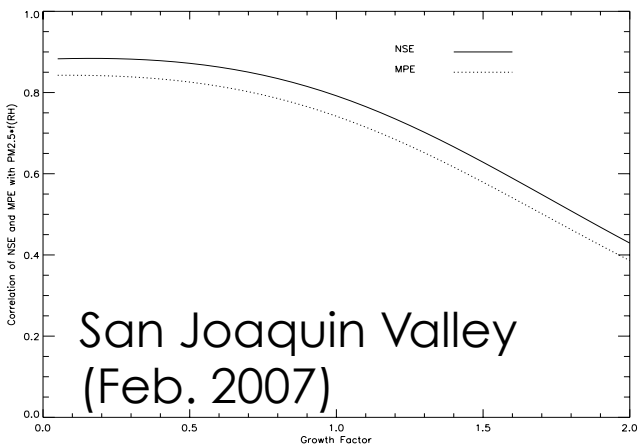
- Δs=0.25°
- f(RH) ?
- aerosol Composition ?

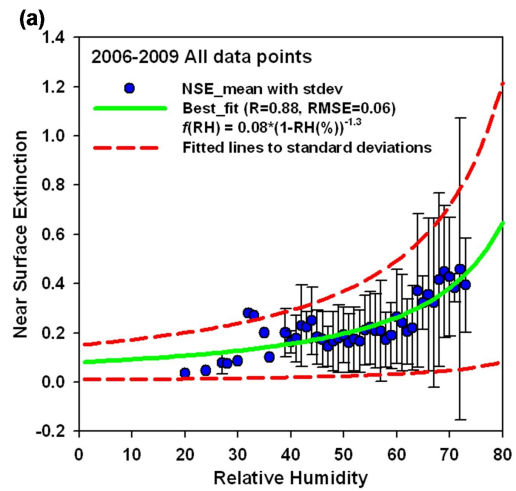
Zero-Order Approximation of Growth Factor

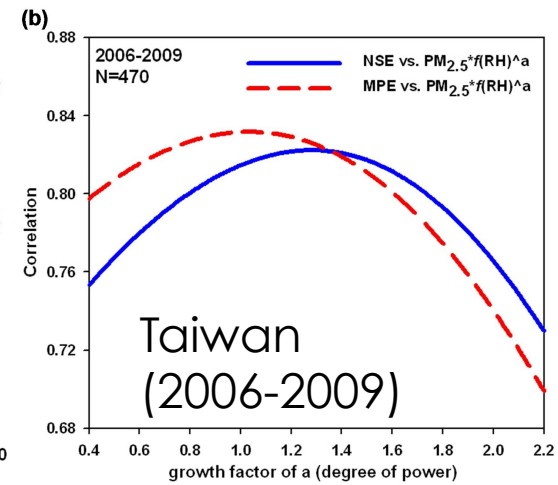
$$PM_{2.5} \approx \frac{\tau_{a,0.55\mu m}}{[f(RH)\sigma^{ext}_{dry,0.55\mu m}]_{surface} L_{mix}}$$

$$PM_{2.5} \bullet f(RH) \approx NSE(orMPE)$$

$$f(RH) = (1 - RH)^{-\varepsilon}$$





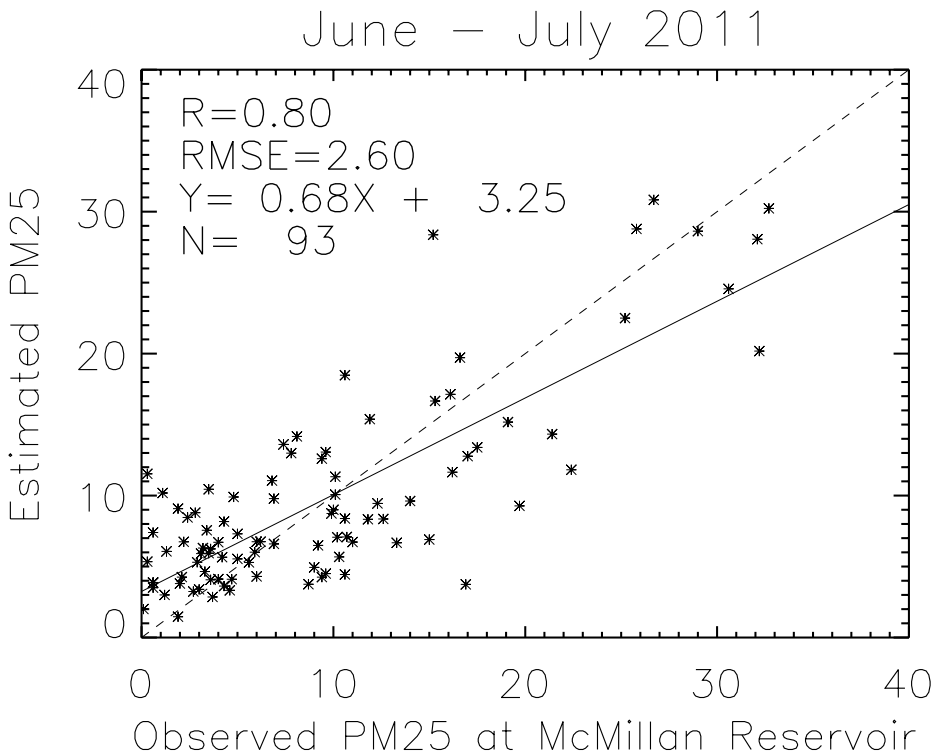


>> The idea is to constrain f(RH) within a reasonable range
>> MPLNet HLH & AERONET AOD observed at GSFC
>> $PM_{2.5}$ observed at McMillan Reservoir
>> Need to revisit f(RH)

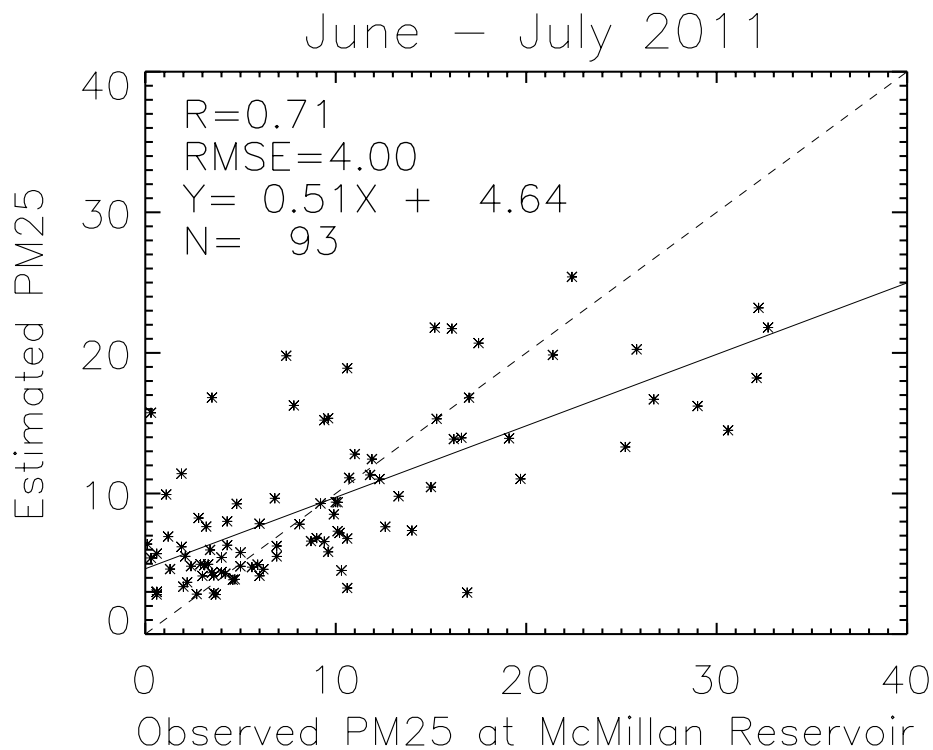
DISCOVER-AQ

Comparison of Estimated and Observed at McMillan Reservoir (mean $PM_{2.5}$ = 9.45 and std = 8.09 $\mu g/m^3$)

$PM_{2.5}$ ~ AOD/(HLH* f(RH))



$PM_{2.5}$ ~ AOD



>> Not collocated (room for improvement with collocated DISCOVER-AQ data)
>> MPLNet HLH & AERONET AOD observed at GSFC
>> $PM_{2.5}$ observed at McMillan Reservoir
>> Need to revisit f(RH)

DISCOVER-AQ

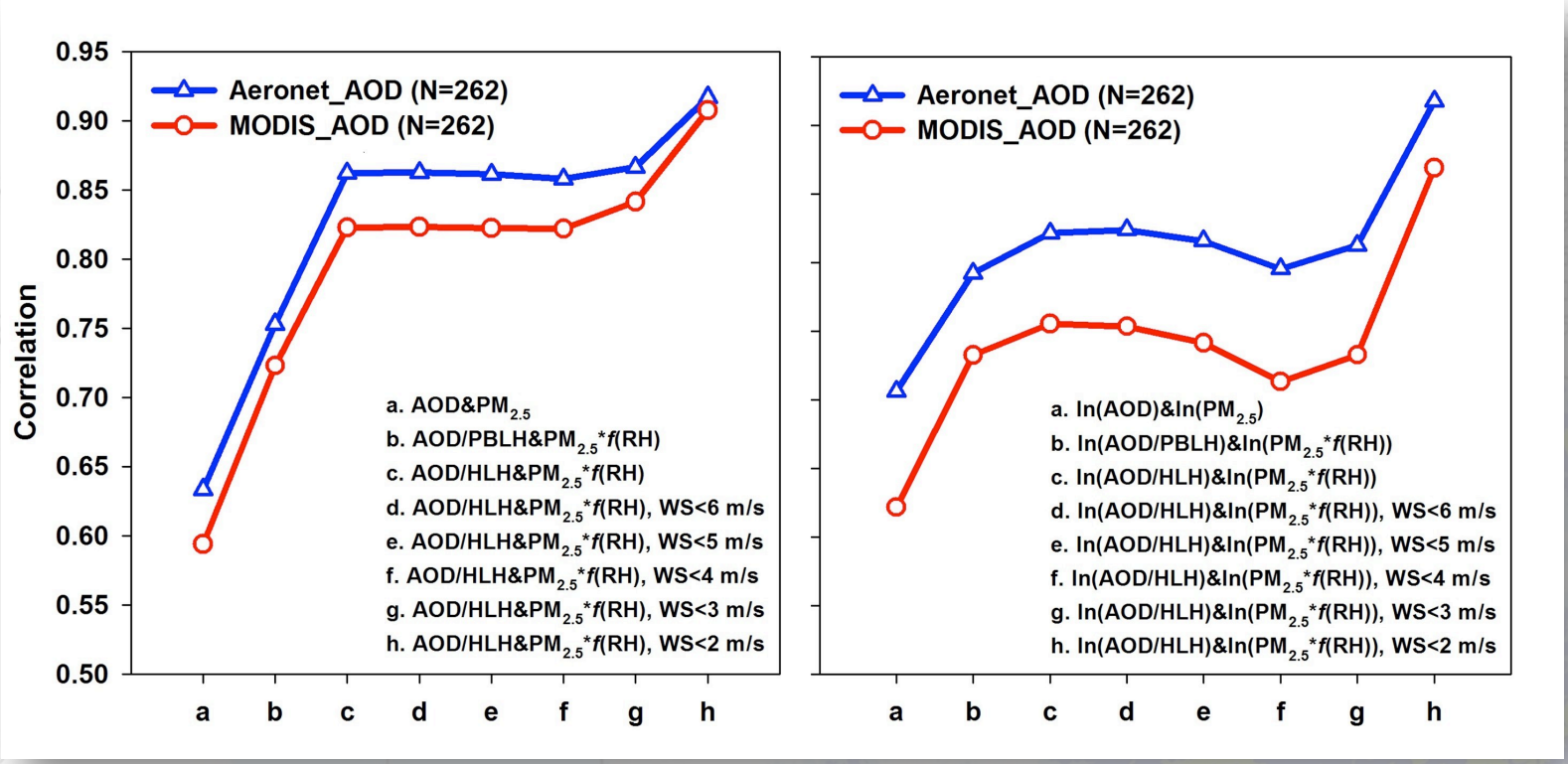
Correlation of 10-year MODIS high resolution (2-km) AOD with AEROENT at GSFC as a function of distance and time intervals

	Time Categories	Time Interval (hour)				
Distance Interval (degree)	Distance Category	0-1	1-2	2-3	3-4	4-5
	0 - 0.1	0.85 (616)	0.85 (641)	0.80 (620)	0.79 (562)	0.77 (458)
	0.1 to 0.2	0.87 (733)	0.86 (784)	0.83 (760)	0.81 (693)	0.79 (575)
	0.2 to 0.3	0.86 (783)	0.87 (842)	0.82 (822)	0.76 (746)	0.77 (623)
	0.3 to 0.4	0.86 (815)	0.86 (883)	0.82 (869)	0.80 (790)	0.79 (661)
	0.4 to 0.5	0.86 (816)	0.86 (889)	0.82 (880)	0.76 (807)	0.77 (677)

MODIS 2-km AOD are generated from research code

DISCOVER-AQ

Correlation of Relationship Between $PM_{2.5}$ and AOD



Approximation: $[PM_{2.5} \times f(RH)]_{surface}$ $vs.$ $\dfrac{\tau_{a,0.55\mu m}}{L_{mix}}$

Chu et al. (2011)

Future Work

I. MPL extinction profiles at MDE $PM_{2.5}$ sites (Beltsville, UMBC, Edgewood, Fair Hill) for similar analysis as using HSRL airborne measurements

II. Analysis of linear regressions derived by MPLNet (GSFC), HSRL, and MPL to estimate $PM_{2.5}$ at all MDE stations using MODIS AOD as input

III. DRAGON AERONET and HSRL AOD data as ground truth to estimate errors of $PM_{2.5}$ estimated by MODIS AOD data in II.

IV. f(RH) – zero order approximation and comparison with airborne and surface in-situ analysis

GEOS-5 during DISCOVER-AQ Maryland:

Near Surface Meteorology, PBL and Aerosols

Arlindo da Silva[1]

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et al.

(1) Global Modeling and Assimilation Office, NASA/GSFC

(2) Atmospheric Chemistry and Dynamics Branch, NASA/GSFC

(3) GESTAR

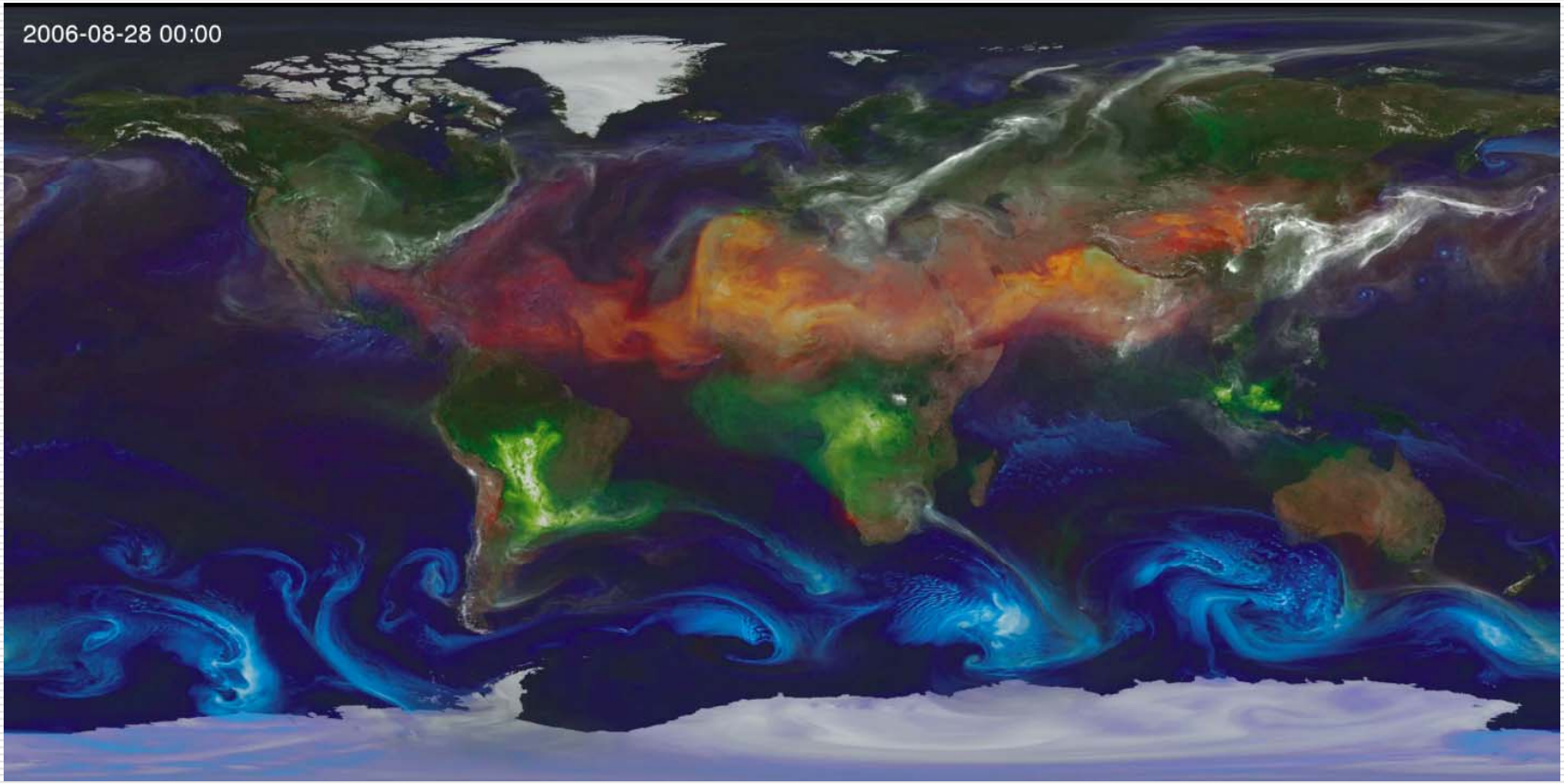
(4) Science Applications International Corp.

DISCOVER-AQ Workshop

Newport News, Virginia

February 14-15, 2012

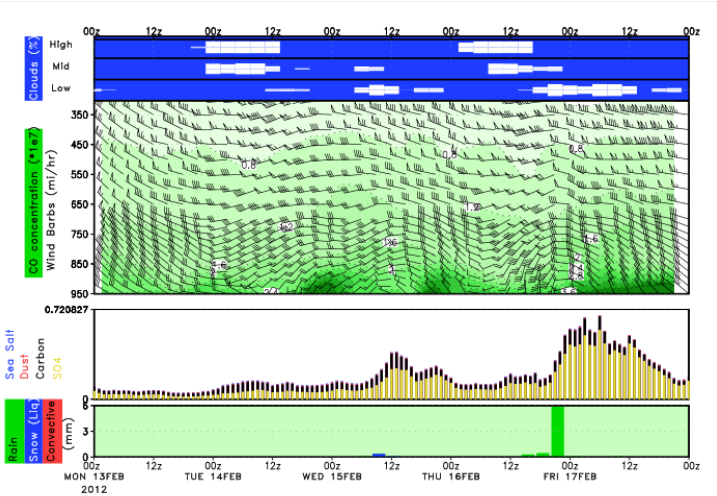
Global GEOS-5 Aerosols

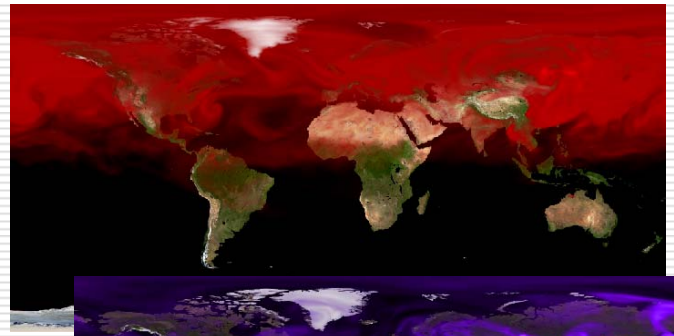


GEOS-5 Forecasting Support

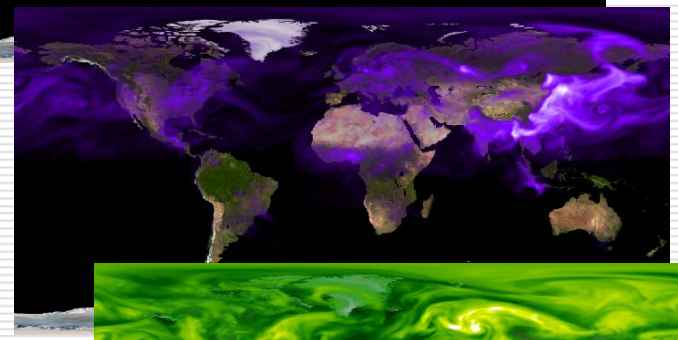
DISCOVER-AQ

- Global 5-day chemical forecasts customized for each campaign
  - O3, aerosols, CO, CO_2, SO_2
  - Resolution: Nomally 25 km
- Driven by real-time biomass emissions from MODIS
- Aerosols interacts with circulation through radiation

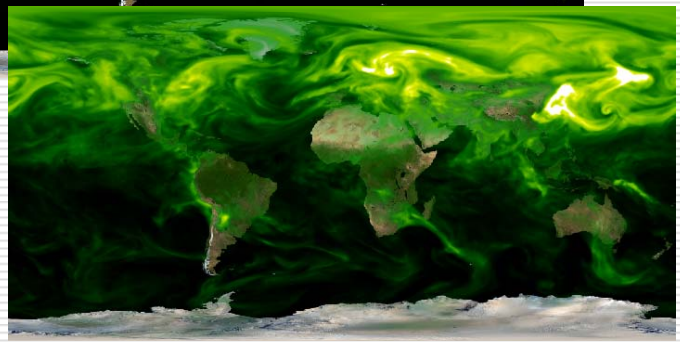




CO



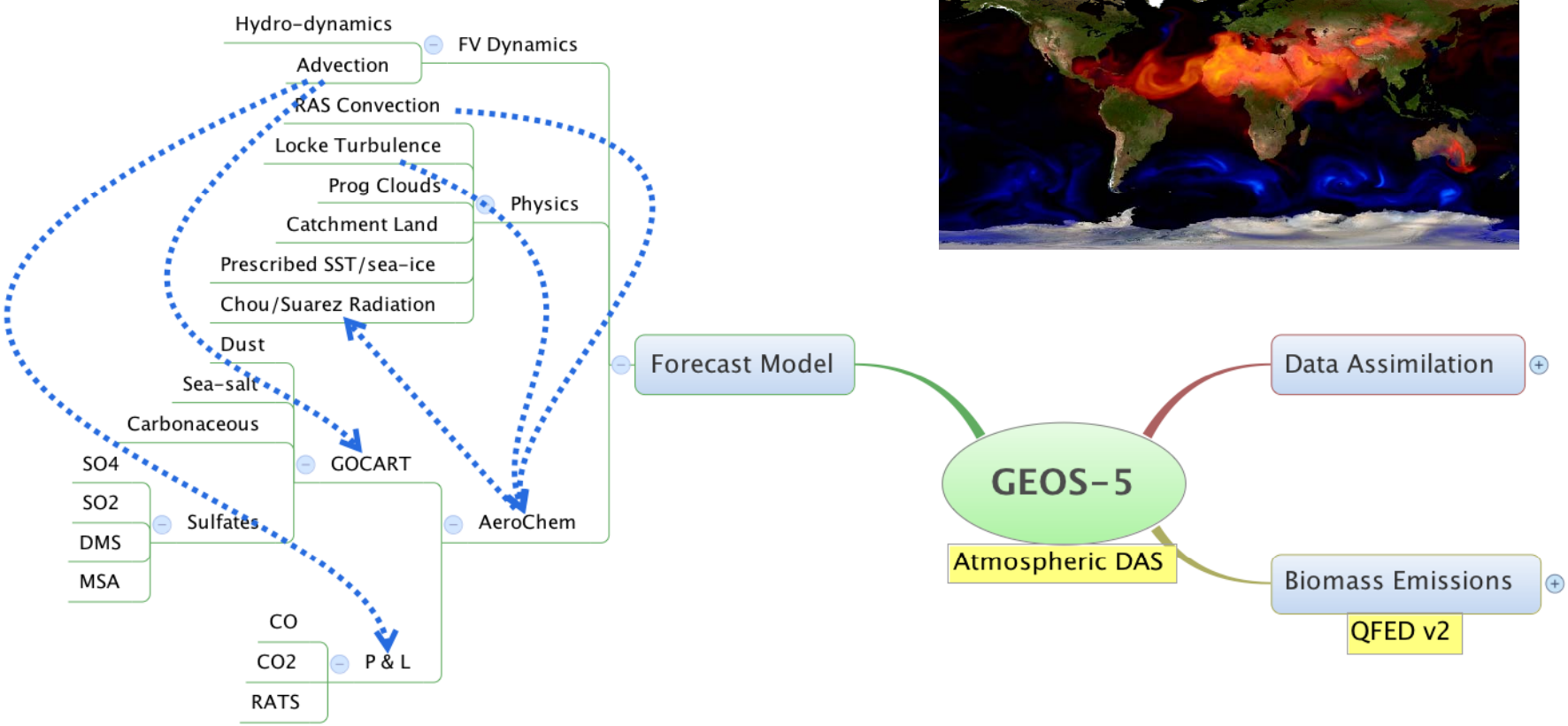
Smoke

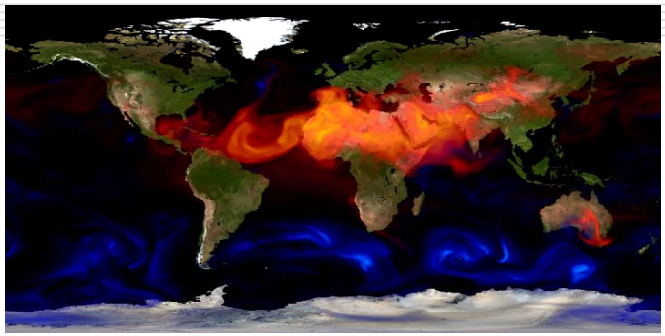


SO_4

http://gmao.gsfc.nasa.gov/projects/DISCOVER-AQ/

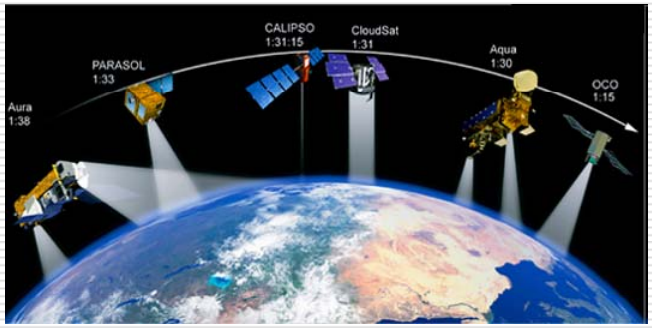
GEOS-5 Atmospheric Data Assimilation System



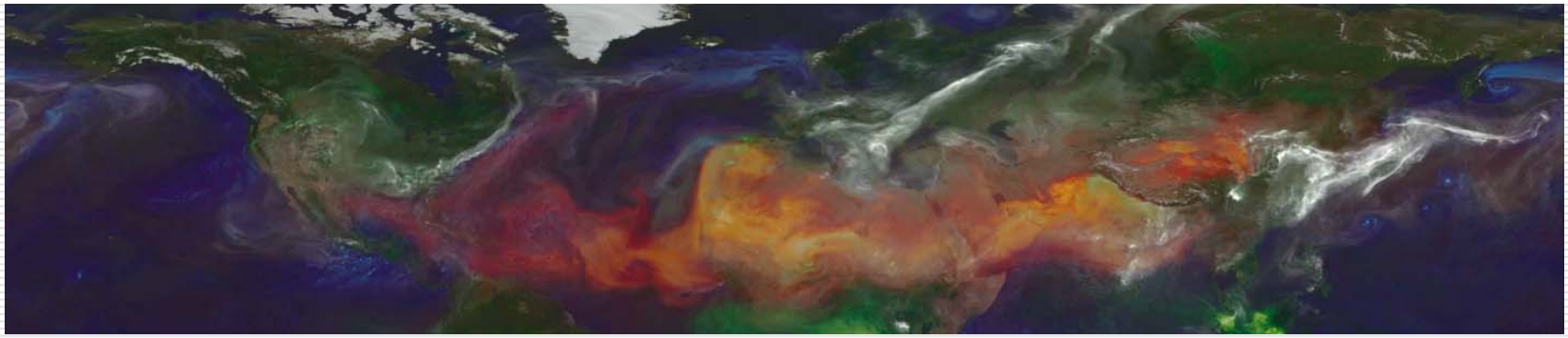


Aerosol Data Assimilation

- Focus on NASA EOS instruments, MODIS for now

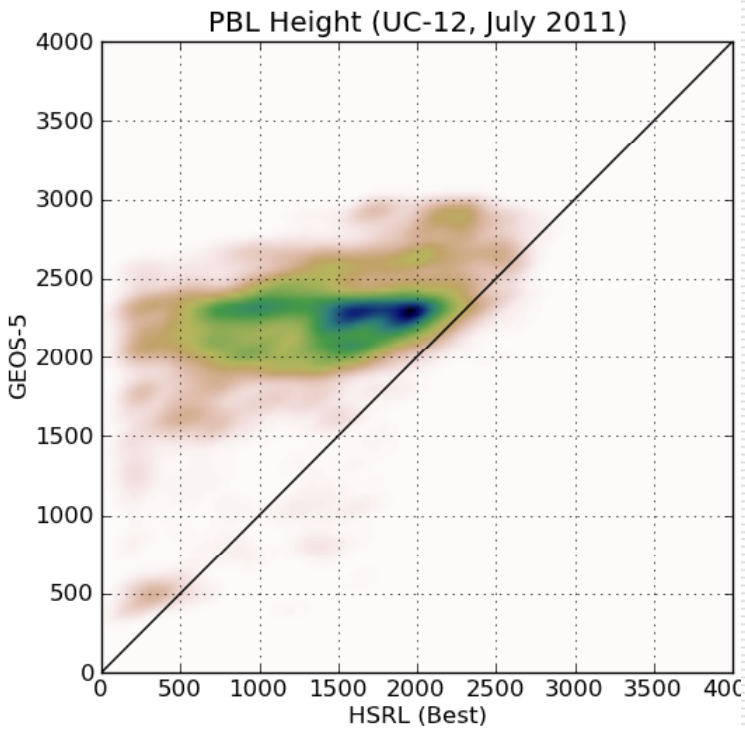


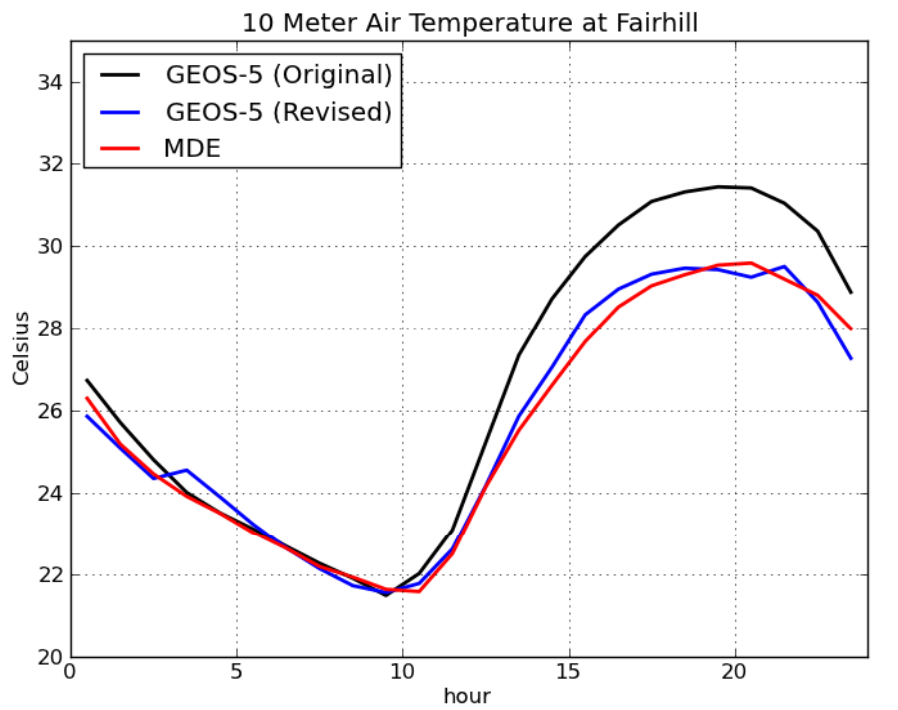
- Global, high resolution (1/4 deg) AOD analysis
- 3D increments by means of Lagrangian Displacement Ensembles (LDE)
- Simultaneous estimates of background bias (*Dee and da Silva 1998*)
- Adaptive Statistical Quality Control (*Dee et al. 1999*):
  - State dependent (adapts to the error of the day)
  - Background and Buddy checks based on log-transformed AOD *innovation*
- Error covariance models (*Dee and da Silva 1999*):
  - Innovation based
  - Maximum likelihood



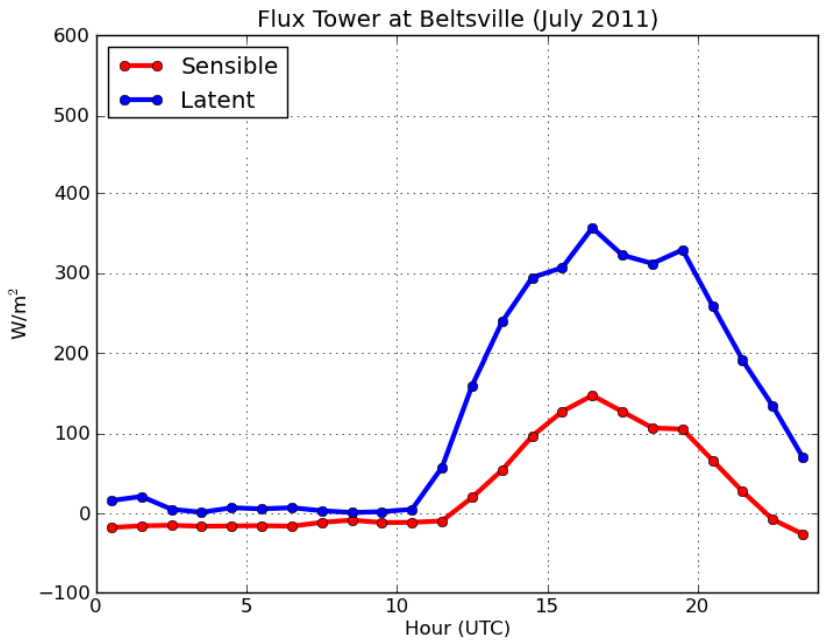
Diagnosing the GEOS-5 Near Real-time System

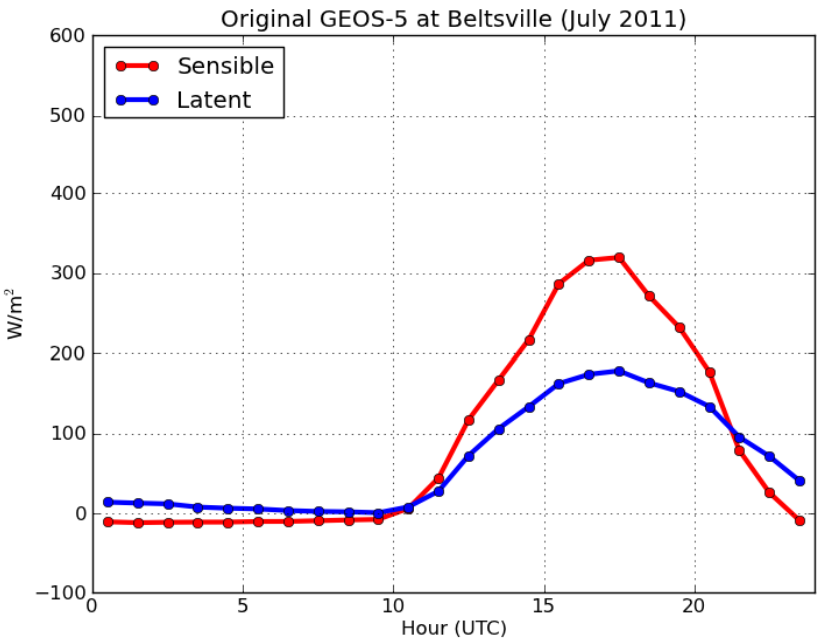
NRT GEOS-5 ADAS
Hot, dry & too deep PBL



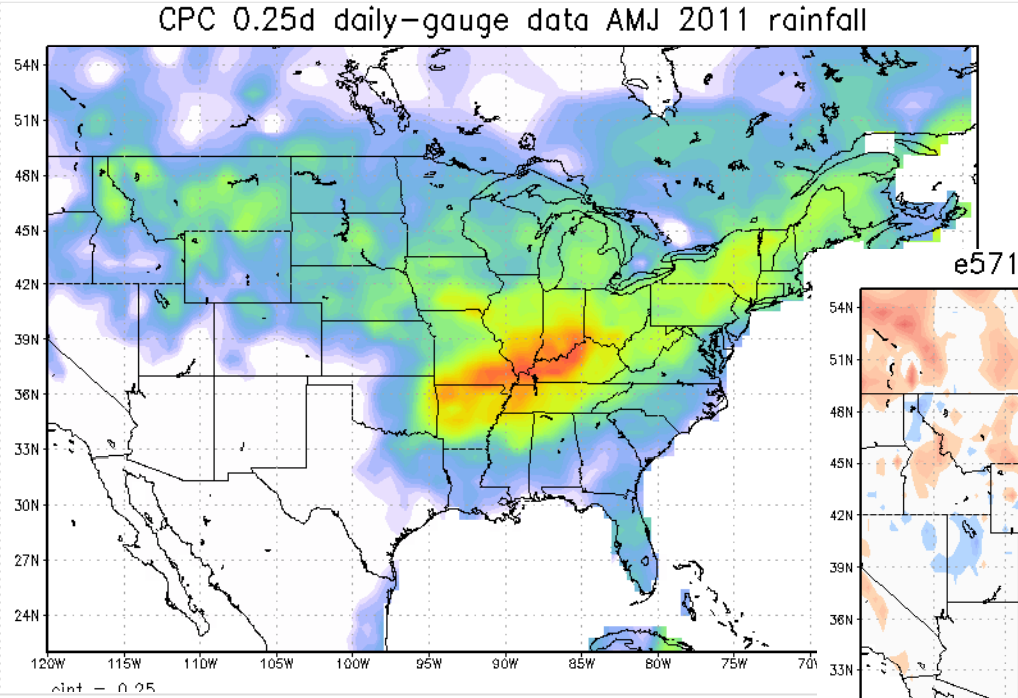


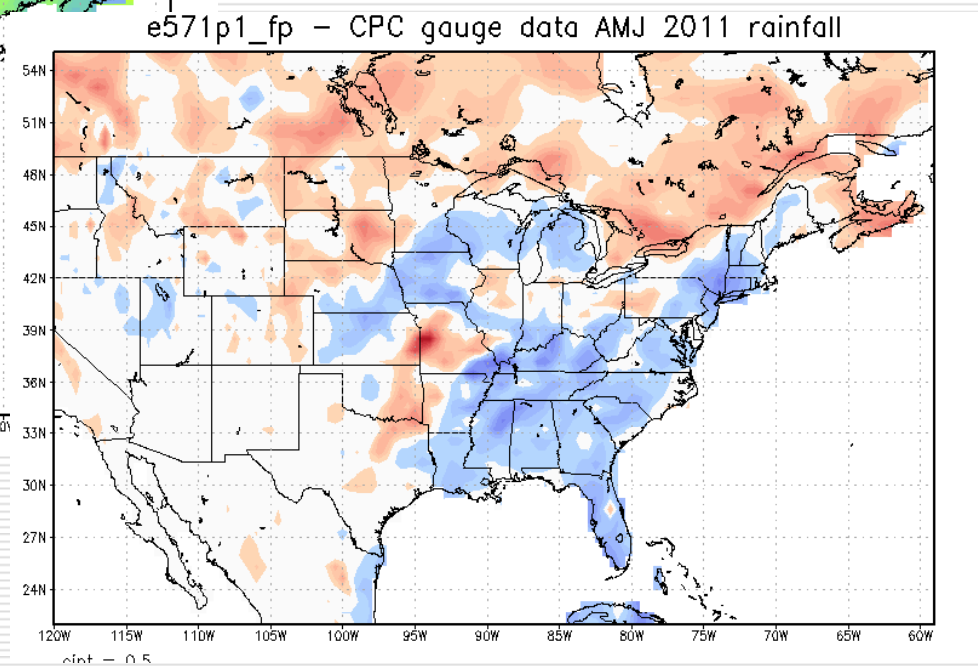
Too little evaporation, Too much sensible heat flux

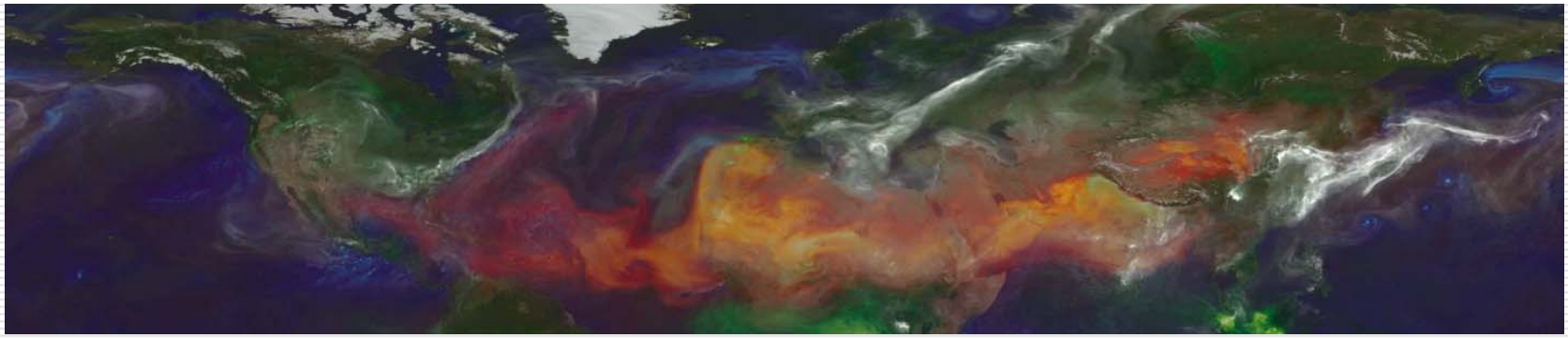




Not enough rain in Spring

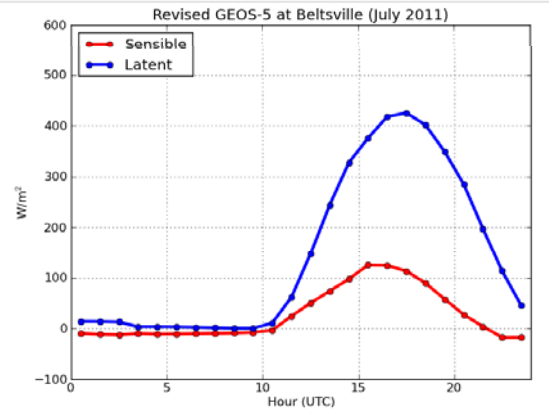


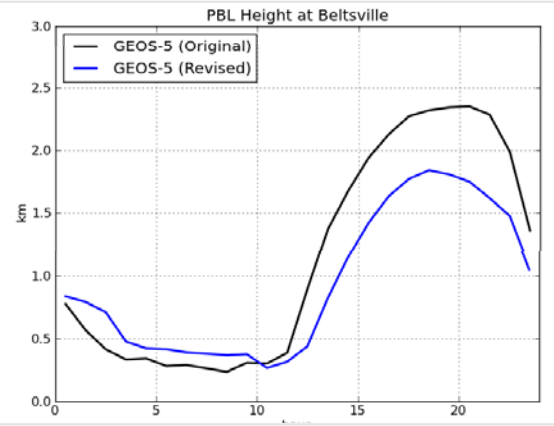


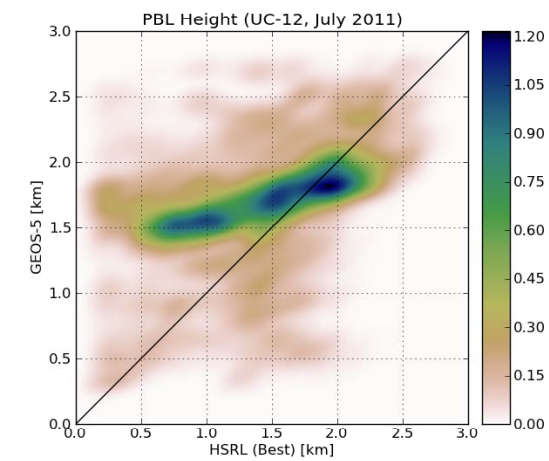


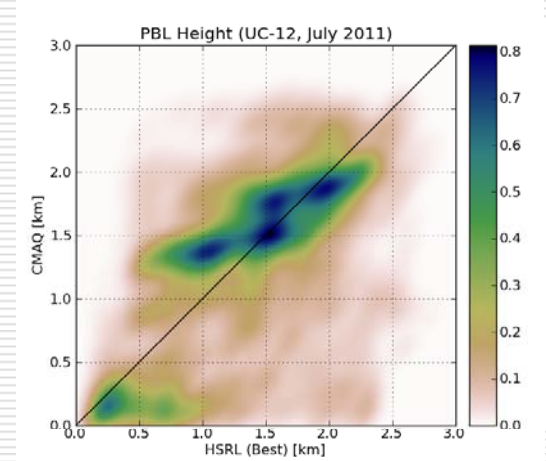
Revised GEOS-5 Atmospheric Data Assimilation System

Fix: Prescribe observed rain, Revise land initial state

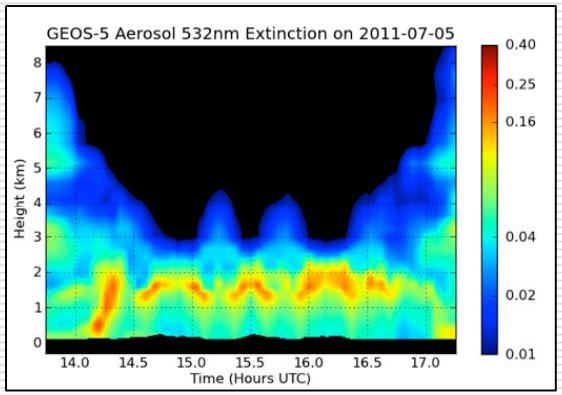


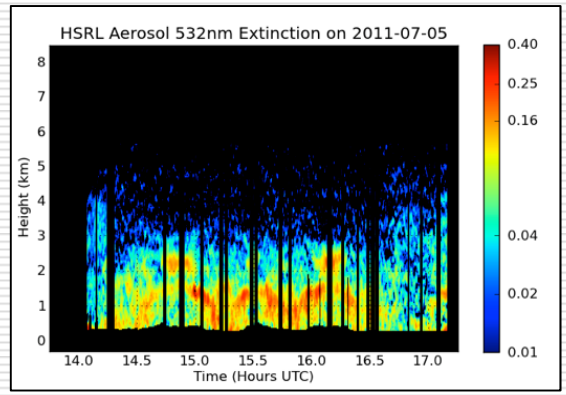


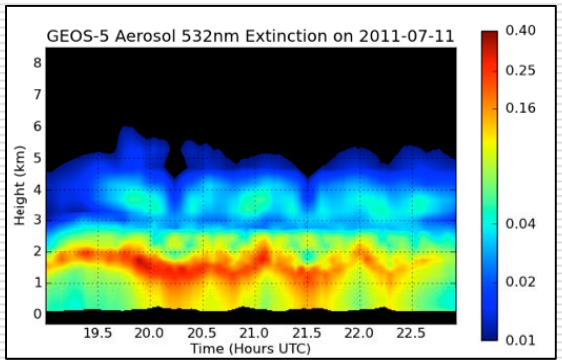


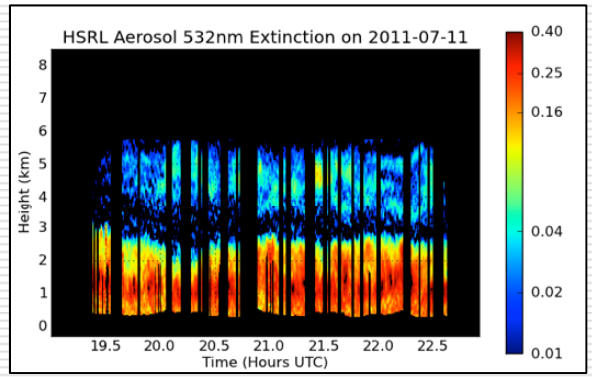


HSRL Extinction Profiles

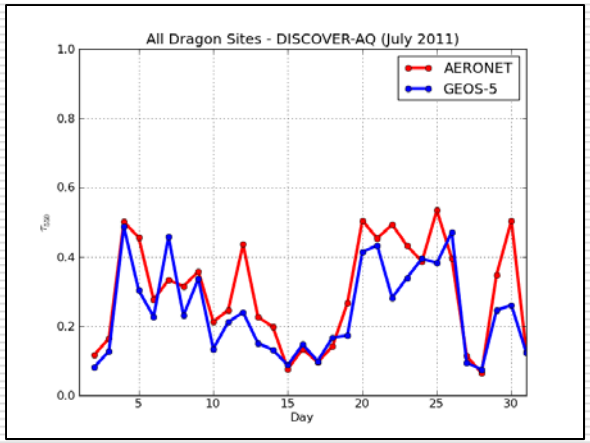


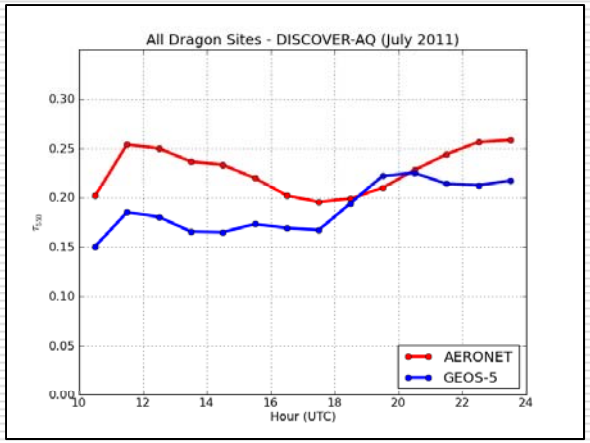


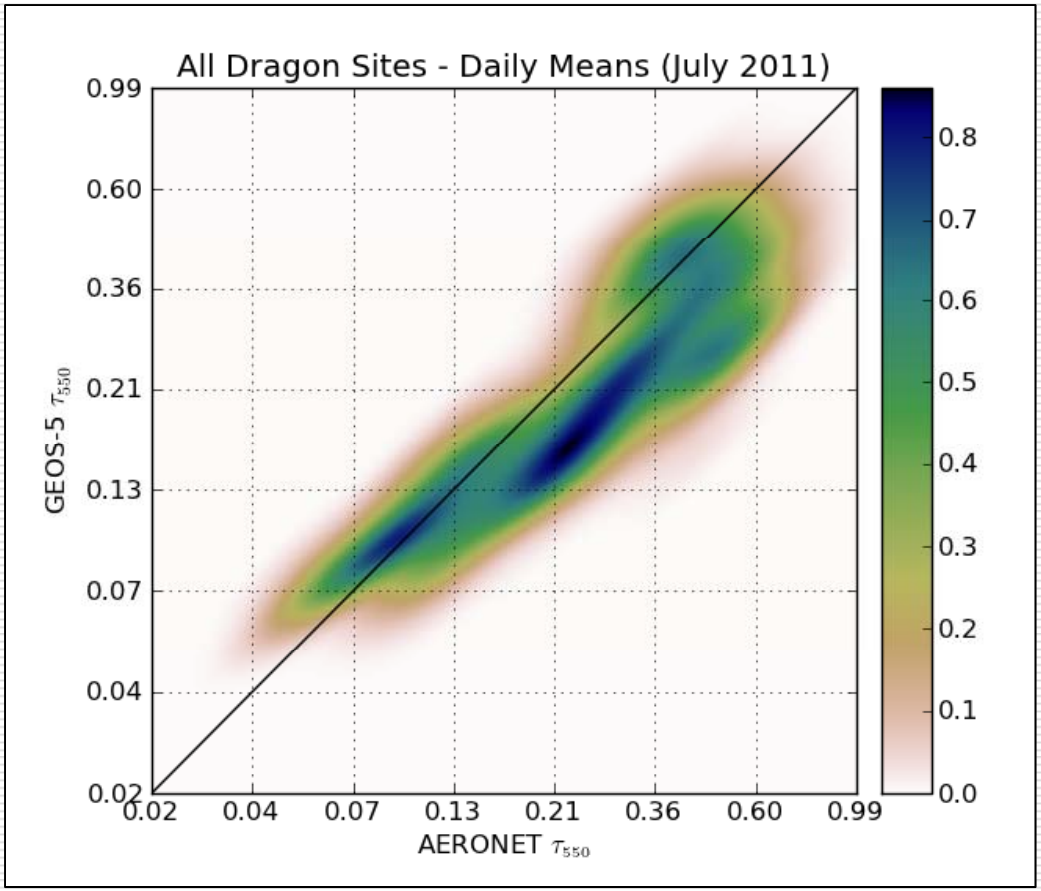




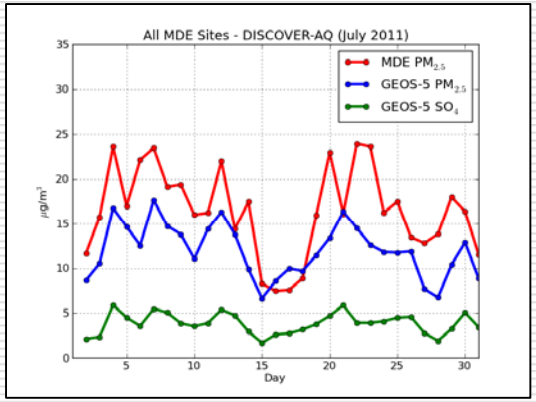
AERONET “DRAGON” Stations

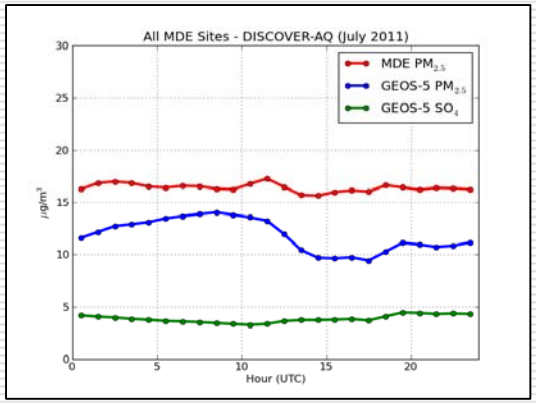


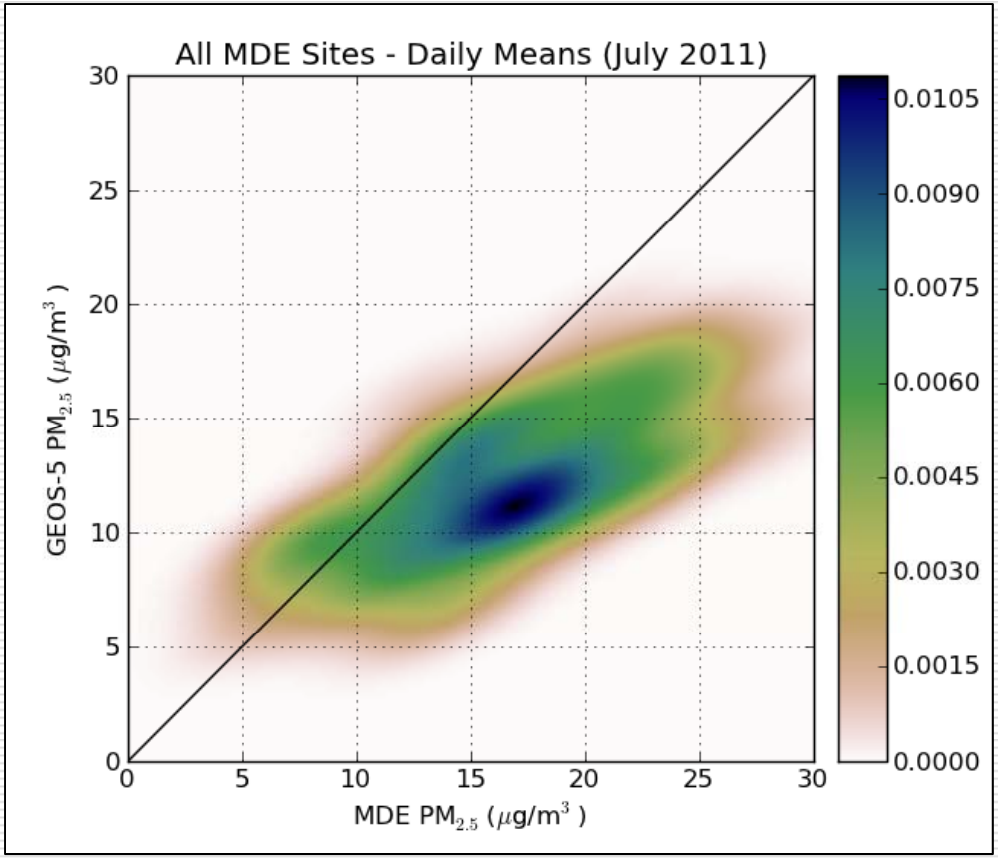




PM 2.5 at MDE Stations







Concluding Remarks

- GEOS-5 captures relatively well day-to-day variability in AOD and PM 2.5
- GEOS-5 shows some skill depicting the aerosol vertical structure
  - PBL still a bit too deep
- GEOS-5 tends to underestimate AOD and PM 2.5 magnitudes
- Twice daily data from MODIS Aqua/Terra not enough to constrain whole day

Future Work

- Further analysis including airborne, sondes and ground-based LIDAR measurements.
- Extend GEOS-5 OMI simulator for ACAM data.
- Evaluate GEOS-5 derived CO and SO_2
- Revision of the GEOS-5 anthropogenic emissions which now consists of out-of-date annual mean inventories.
- Assimilation of GOES derived AOD retrievals in order better constrain GEOS-5.
  - J. Stehr (AGU 11 talk) has shown that GOES AOD retrievals performed very well during DISCOVER-AQ.
- A higher resolution simulation (~10km) using the non-hydrostatic GEOS-5 on the cubed-sphere.

HSRL Measurements and Surface $PM_{2.5}$

Estimation of $PM_{2.5}$ from AOT

$$AOT = \int \alpha(z)\, dz$$

$$AOT \approx \overline{\alpha_H(\text{ambient RH})} \times H$$

Assume: α_{SFC} (ambient RH) ~ $\overline{\alpha_H(\text{ambient RH})}$

α_{SFC} (ambient RH) = f(RH) x α_{SFC} (dry)

Assume: α_{SFC} (dry) ~ b_{sca}(dry)

b_{sca}(dry) = SSC x $PM_{2.5}$

$$AOT \approx f(RH) \times SSC \times H \times PM_{2.5}$$

Where:

α = aerosol extinction

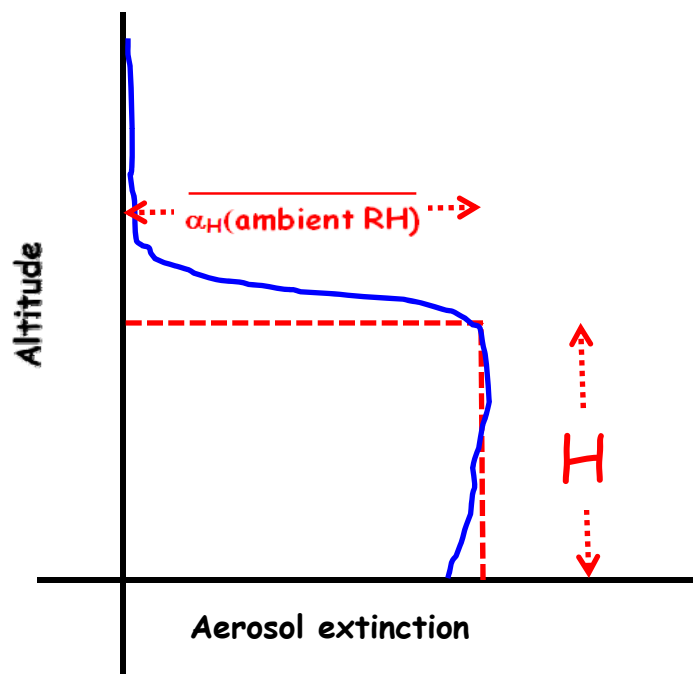
b_{sca} = aerosol scattering

SSC = specific scattering coefficient

f(RH) = aerosol humidification factor

H = height of aerosol layer

$$AOT = \int \alpha(z)\, dz$$



Estimation of $PM_{2.5}$ from AOT: Questions addressed using HSRL data

What to use for H?

PBL height (z_{PBL}) or height of maximum aerosol gradient (z_{AG})?

Can we assume that surface extinction is about the same as the mean extinction in aerosol layer?

α_{SFC} (ambient RH) ~ $\overline{\alpha_H(\text{ambient RH})}$?

How well is surface extinction related to $PM_{2.5}$?

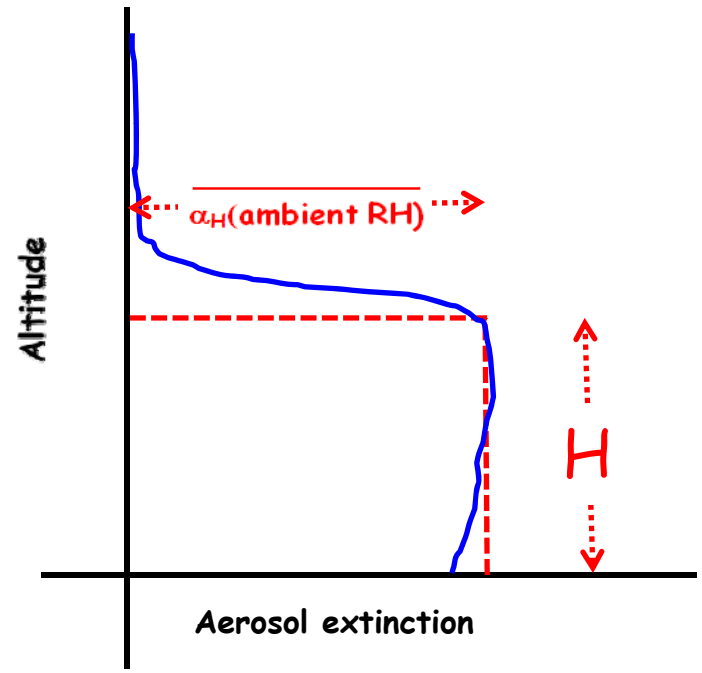
Can we estimate SSC?

α_{SFC} (dry) ~ SSC x $PM_{2.5}$?

How well is AOT correlated with:

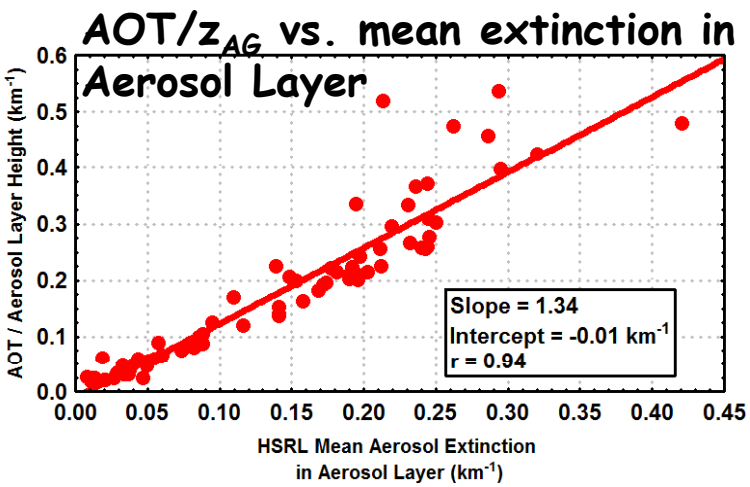
α_{SFC} (ambient RH), α_{SFC} (dry) , $PM_{2.5}$?

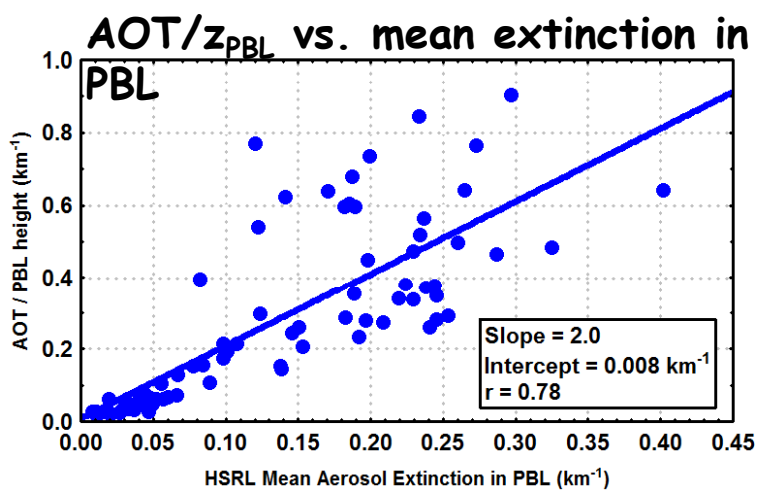
$$AOT = \int \alpha(z)\, dz$$



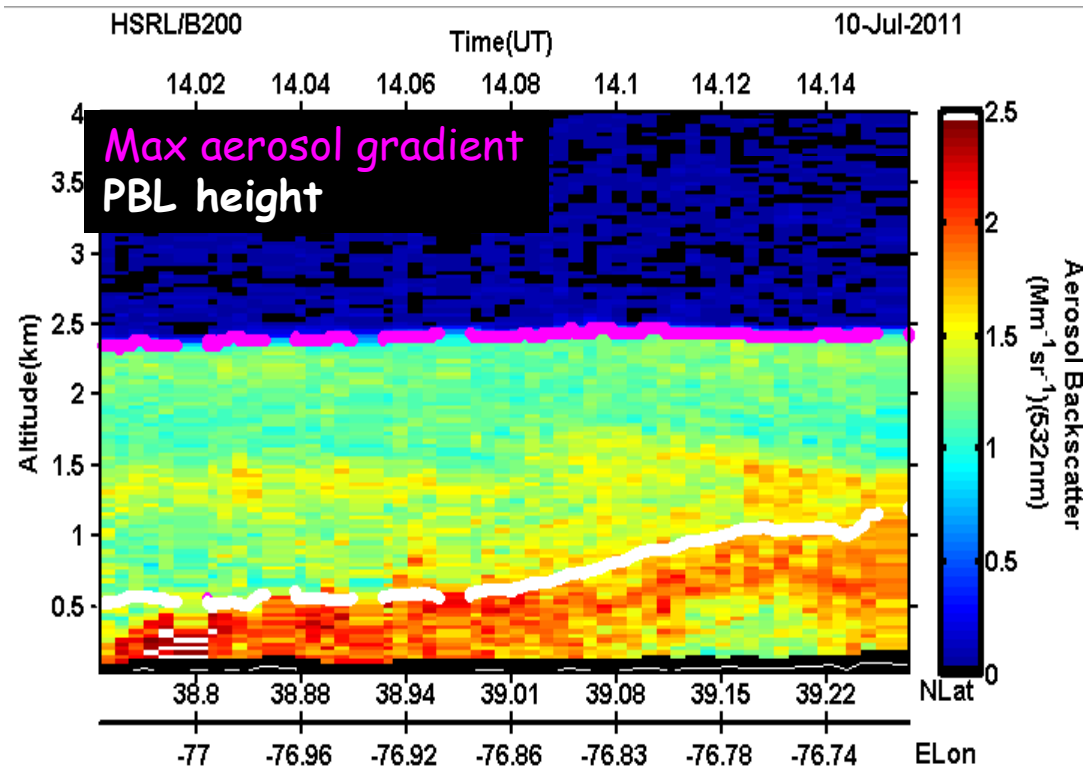
Aerosol Layer Height

We examine AOT / H vs. $\overline{\alpha_H(\text{ambient RH})}$
Where H = z_{PBL} and H = z_{AG}

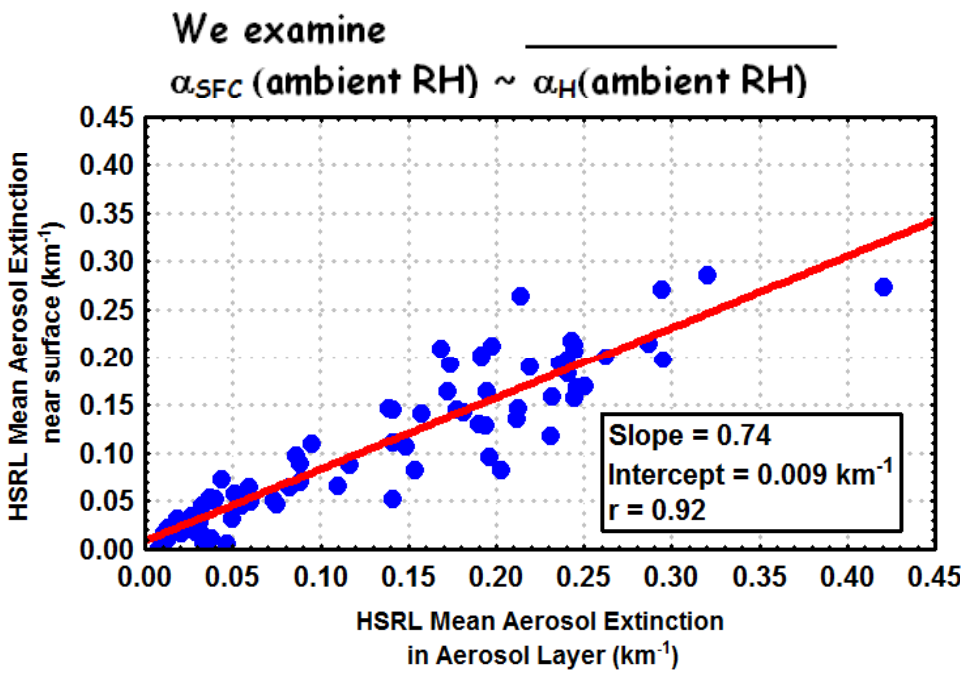


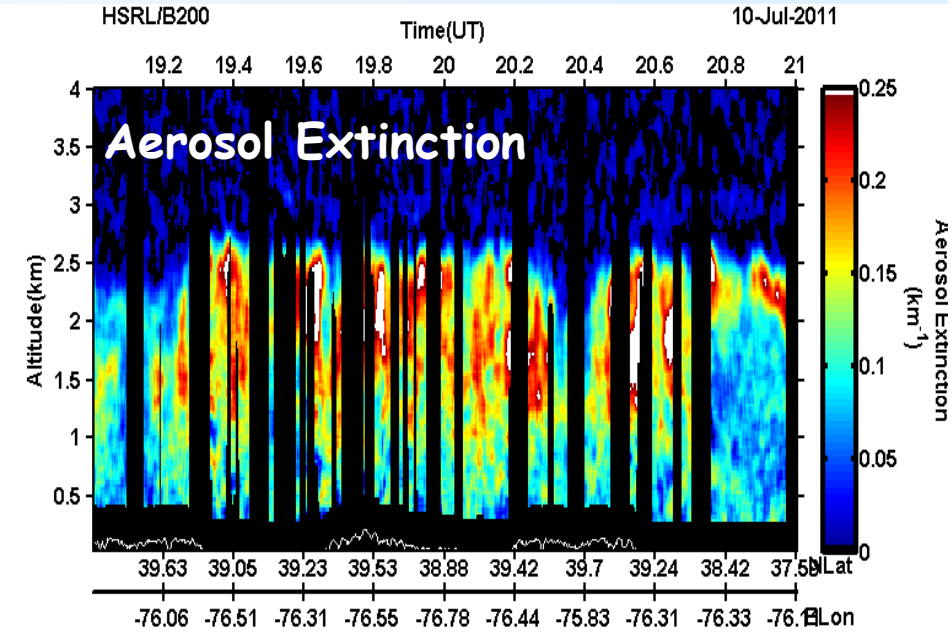


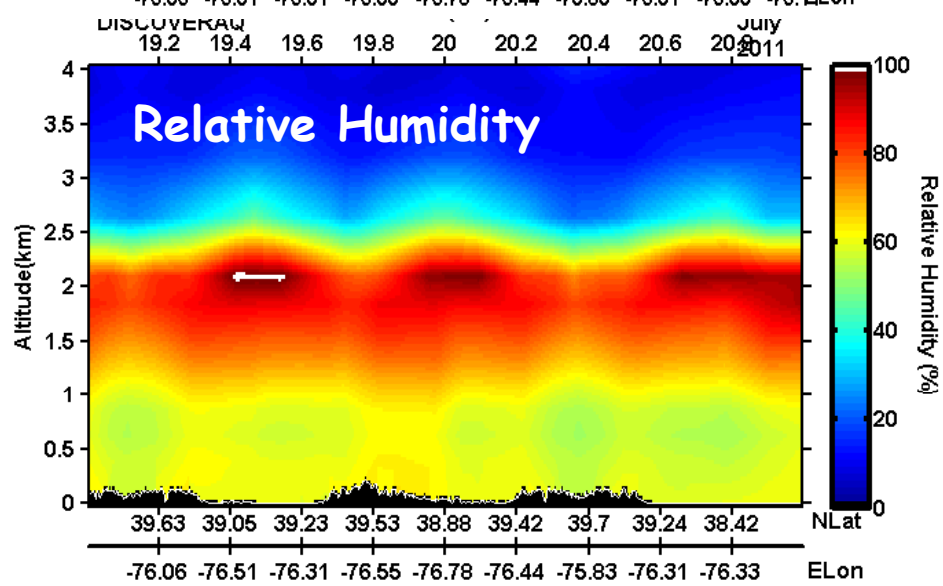
- We investigate the impact of layer height by examining the correlation between AOT and mean extinction within PBL and aerosol layer
- HSRL measurements coincident with hourly surface $PM_{2.5}$ data from four stations (Beltsville, Fairhill, Edgewood, UMBC)
- Height of the maximum aerosol gradient (aka aerosol layer) is a better measure of scale height than PBL height (but not the best)



Relationship between mean layer extinction and surface extinction



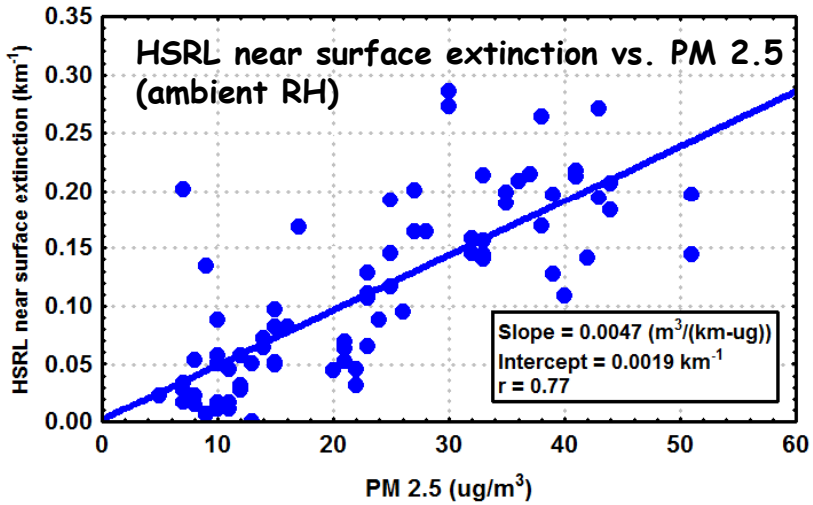


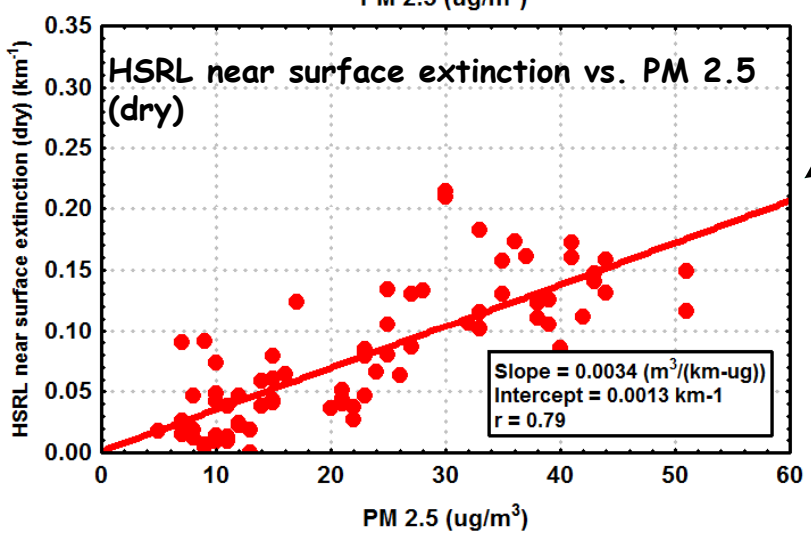


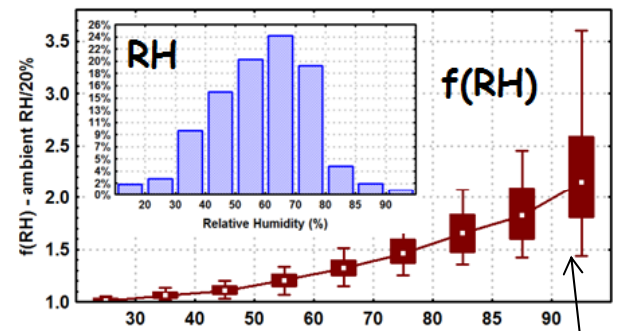
- Surface extinction is well correlated with mean aerosol extinction in the layer
- Surface extinction is generally lower than mean extinction in the layer
  - HSRL data often show increase in extinction with height in aerosol layer
  - This increase likely associated with higher RH near the top of the layer

Correlation between near-surface extinction and surface $PM_{2.5}$ concentrations

- HSRL measurements of extinction near the surface were correlated with hourly surface $PM_{2.5}$ data from four stations (Beltsville, Fairhill, Edgewood, UMBC)
- Average humidification factor was obtained from P3 in situ data
- Correlations would likely improve with higher temporal resolution surface $PM_{2.5}$ data







We examine

$\alpha_{SFC}(dry) \approx SSC * PM_{2.5}$

$\alpha_{SFC}(ambient\ RH)/f(RH) \approx SSC * PM_{2.5}$

Used average f(RH) correction derived from P3

Slope = ~ 3.4 m^2/g

(recall from Hoff et al. Nov. 3 presentation SSC from surface BAM = 3.2 ± 1.3 m^2/g)

where:

α = aerosol extinction

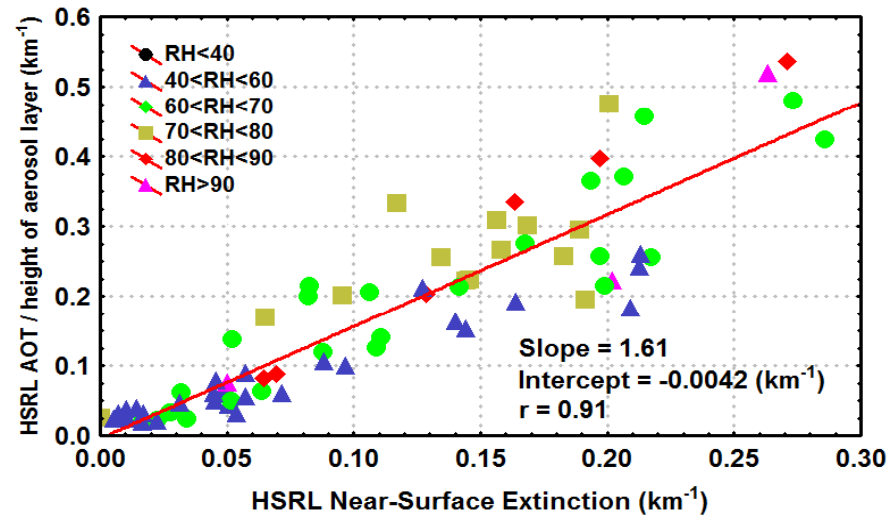
SSC = specific scattering coefficient

f(RH) = humidification factor

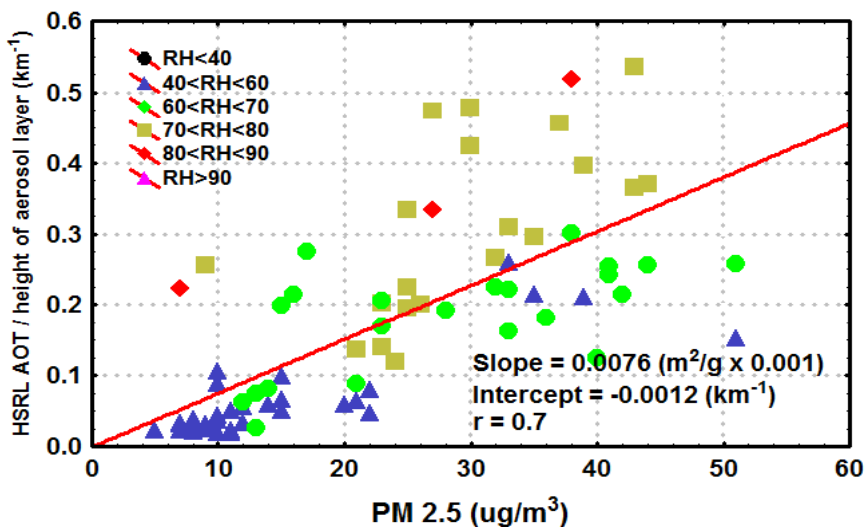
Correlation between HSRL AOT and $PM_{2.5}$

- Surface $PM_{2.5}$ can be inferred from measurements of AOT and height of the aerosol layer
- Highest correlation between HSRL AOT scaled by height of aerosol layer and HSRL near-surface extinction
- Correlations would likely improve with:
  - higher temporal resolution surface $PM_{2.5}$ data
  - use of individual f(RH, z) measurements rather than an average f(RH)

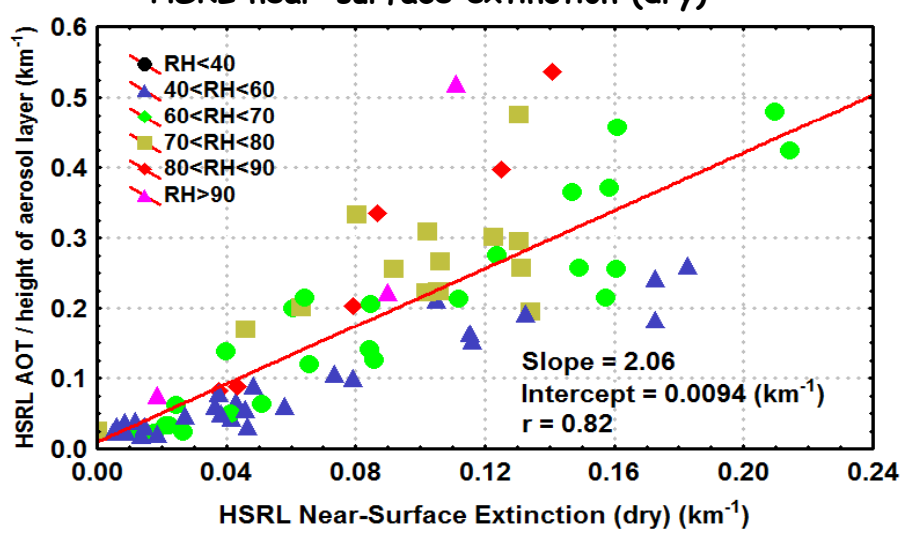
(HSRL AOT / aerosol layer height) vs. HSRL near-surface extinction (ambient RH)

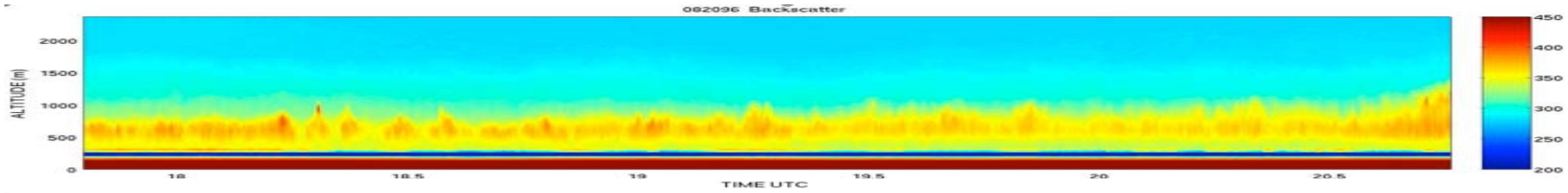


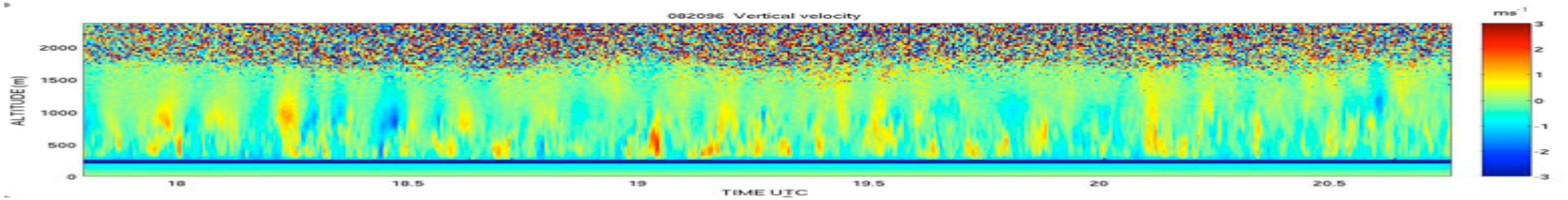
(HSRL AOT / aerosol layer height) vs. PM 2.5

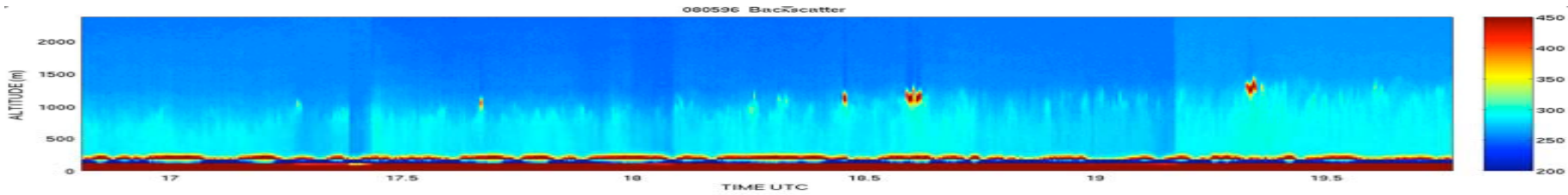


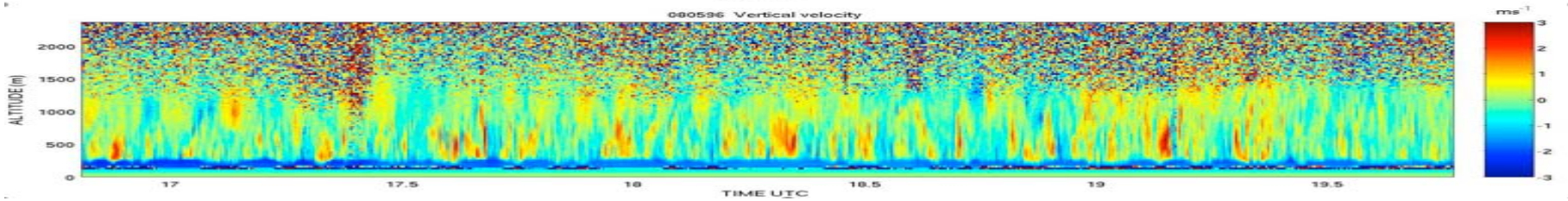
(HSRL AOT / aerosol layer height) vs. HSRL near-surface extinction (dry)

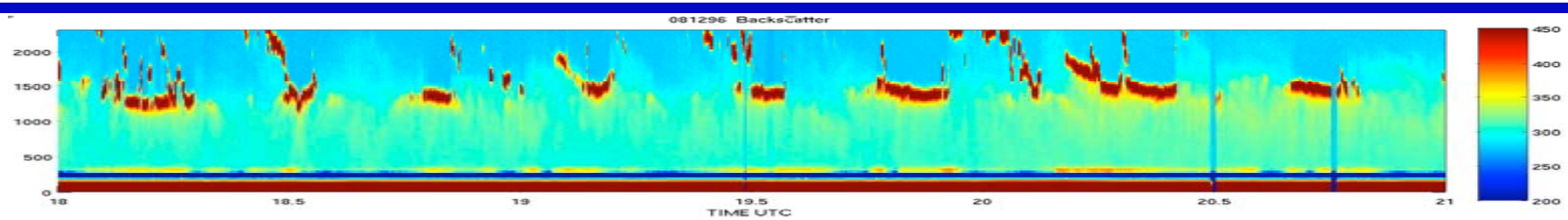


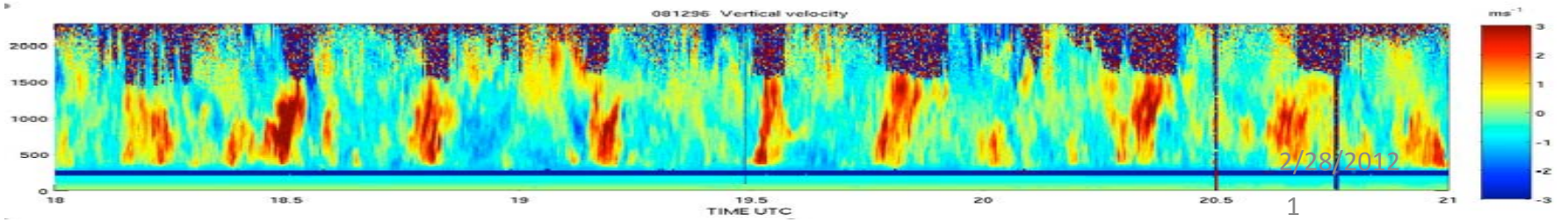

082096 Backscatter
ALTITUDE (m)
TIME UTC

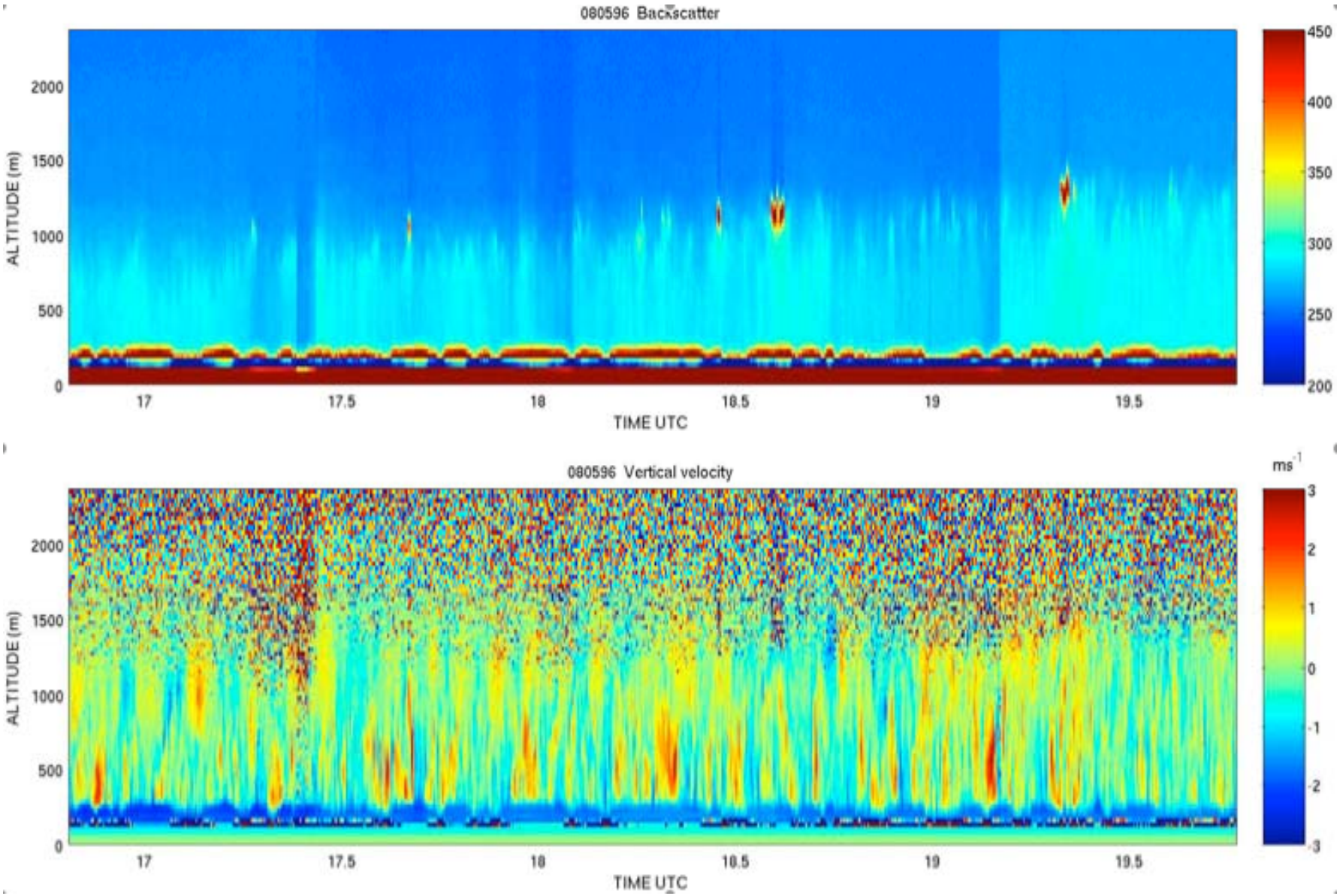

082096 Vertical velocity
ALTITUDE (m)
TIME UTC
ms⁻¹


080596 Backscatter
ALTITUDE (m)
TIME UTC

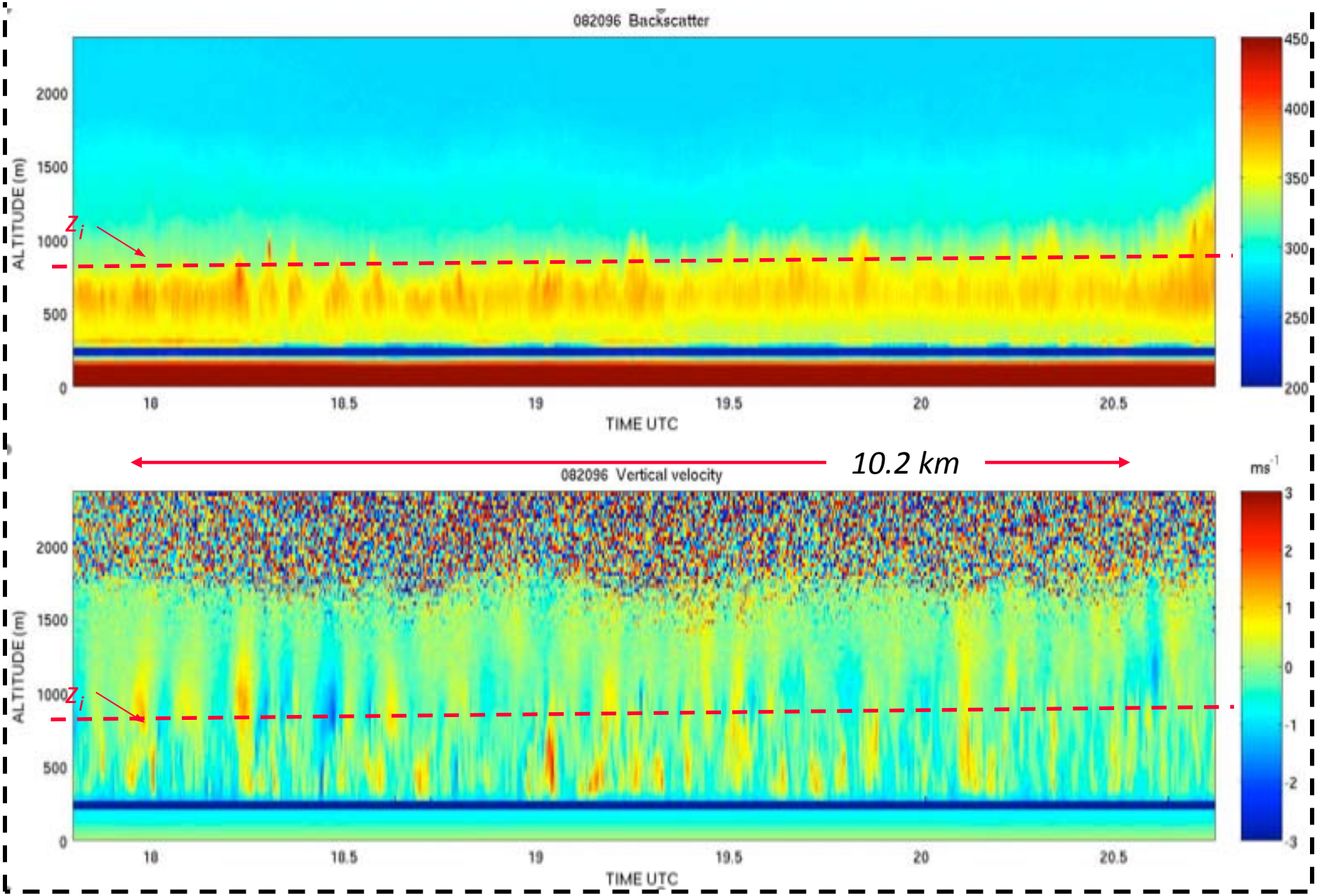

080596 Vertical velocity
ALTITUDE (m)
TIME UTC
ms⁻¹


081296 Backscatter
TIME UTC

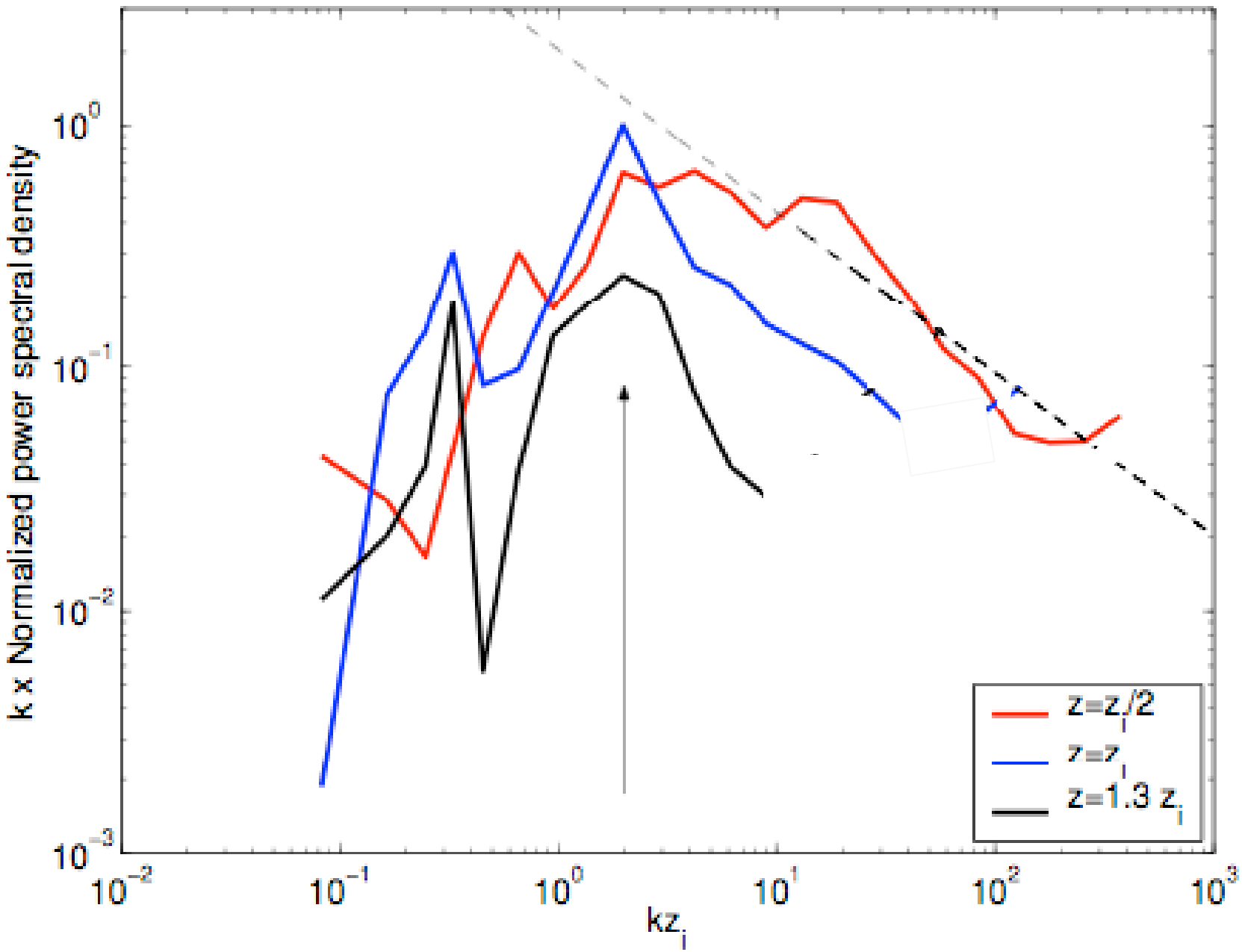

081296 Vertical velocity
TIME UTC
ms⁻¹



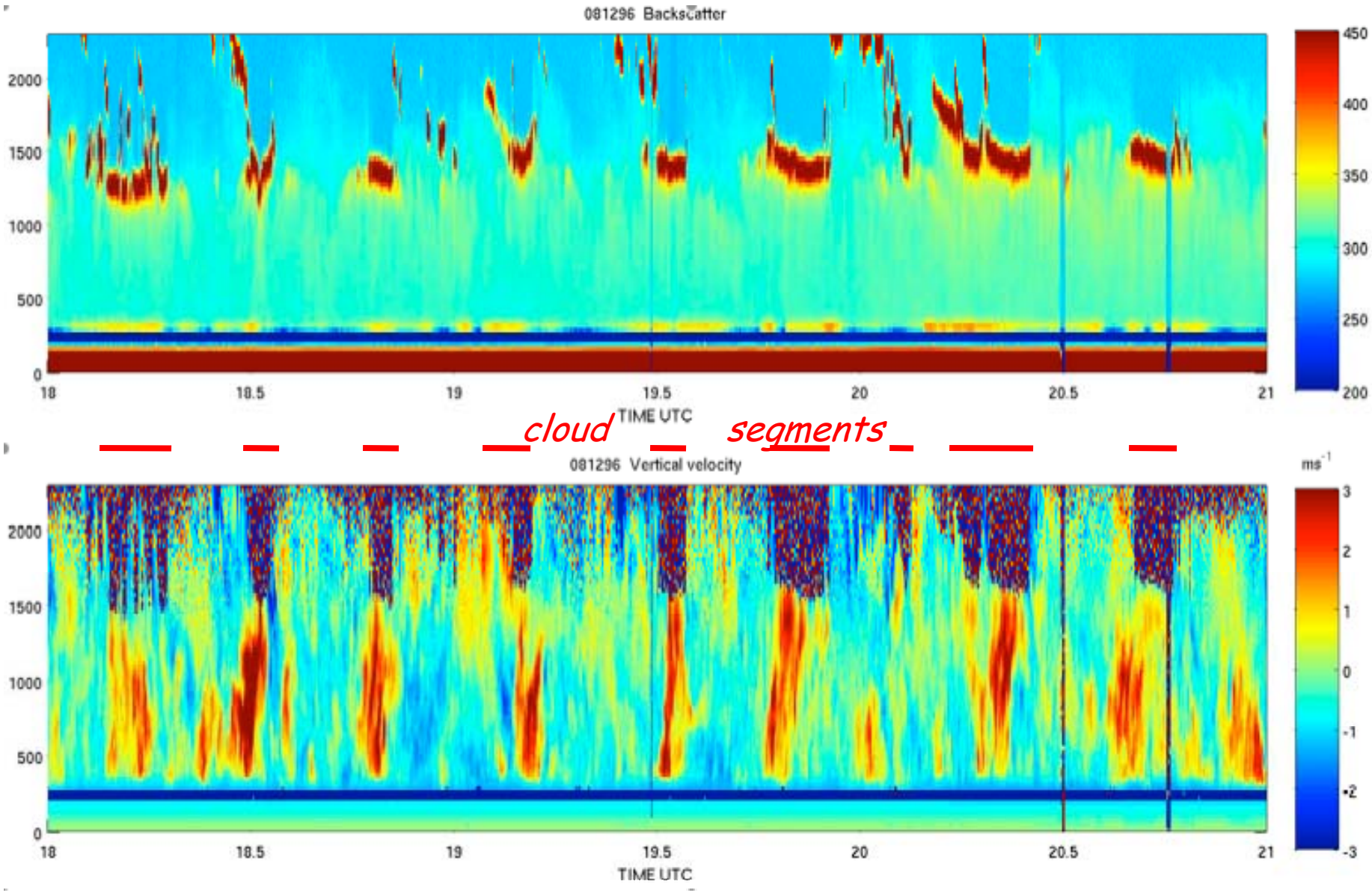
High-Resolution Doppler Lidar (HRDL) measurements *w* from LIFT on 5 August 1996; a typical fair-weather day.



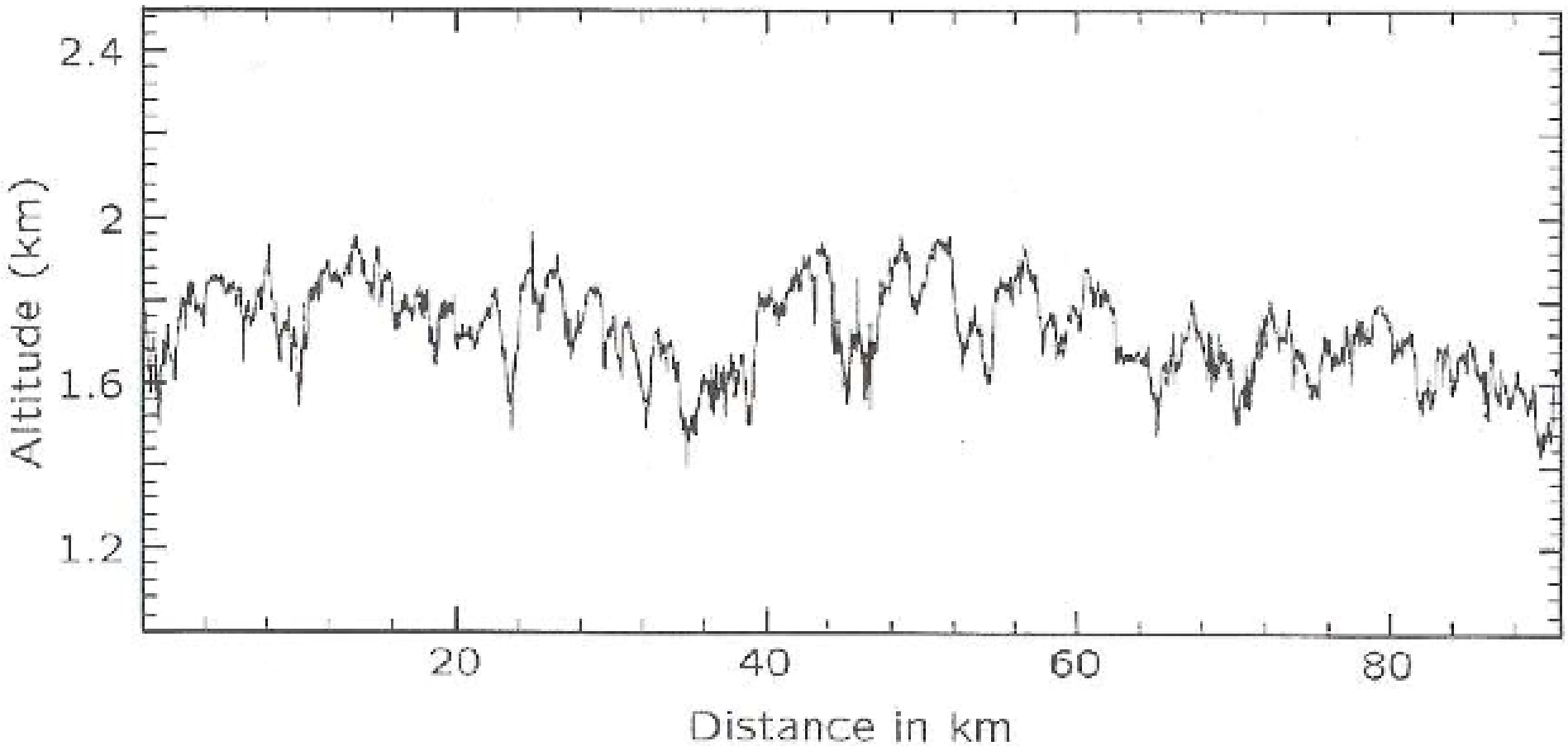
High-Resolution Doppler Lidar (HRDL) measurements *w* from LIFT on 20 August 1996. z_i = 960 m, U = 6.8 m/s, ΔU = 3.1 m/s, $\partial\theta/\partial z$ = 1.2 C/km in FT.



w spectrum at 3 levels on 20 August 1996



High-Resolution Doppler Lidar (HRDL) measurements *w* from LIFT on 12 August 1996; CBL modulated by fair-weather cumulus.



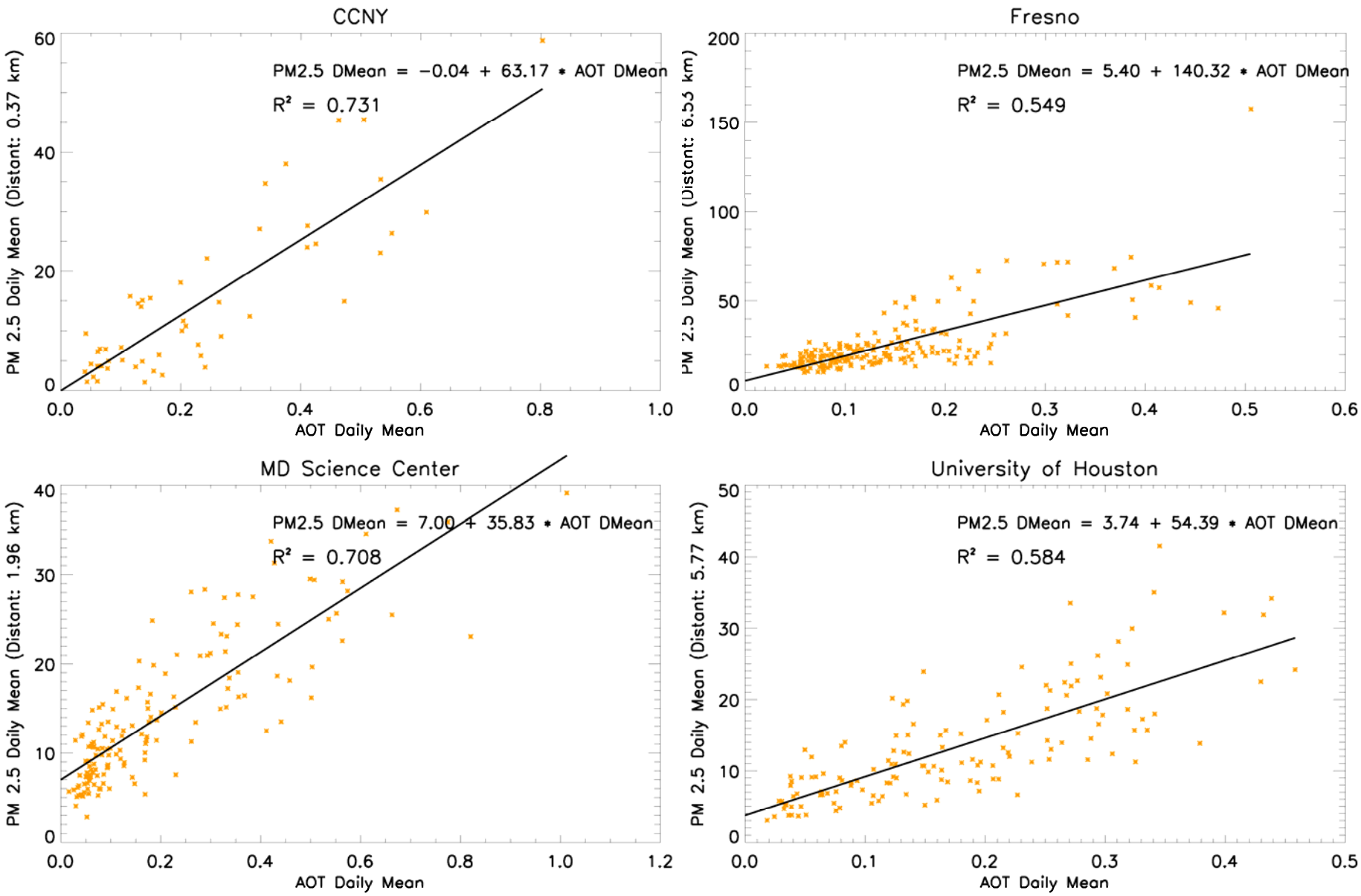
Plot of boundary-layer height measured with a downward-pointing airborne lidar. The height is determined by the maximum gradient in backscatter. The length scale of maximum variance appears visually to be a few km. (The lidar and observational study are described by Kiemle et al., 1997.)

<u>Question</u>: is it possible to derive the aerosol diurnal variation within PBL using column integrated aerosol optical depth? I.e. can we use geostationary satellite observations to study and monitor air quality on time scale finer than once or twice a day.

Analyze two ground-based networks:

-- EPA's hourly PM2.5 observation (~ 200-400 sites)

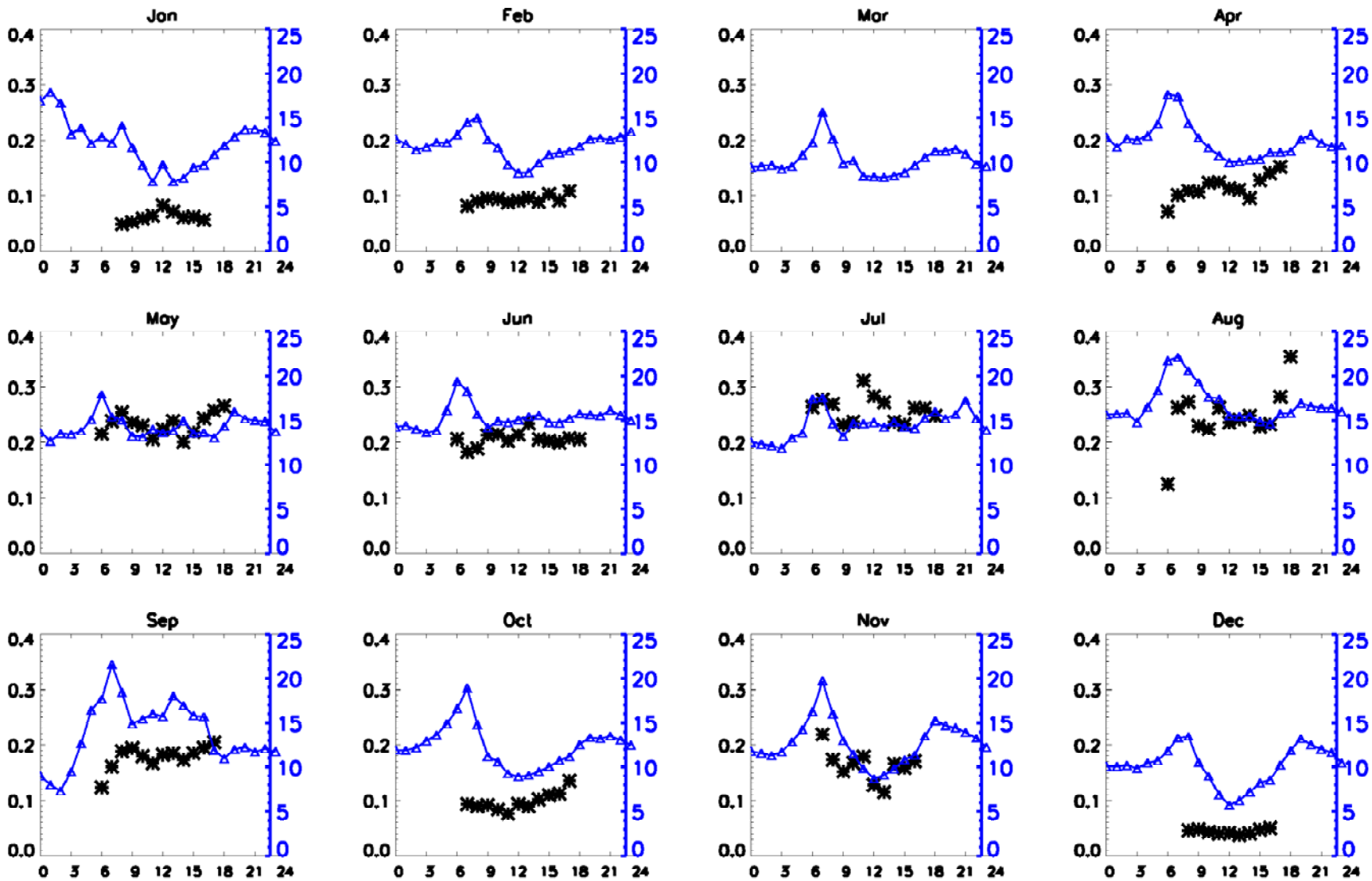
-- NASA AERONET high frequency AOT observation (~ 40-50 sites)



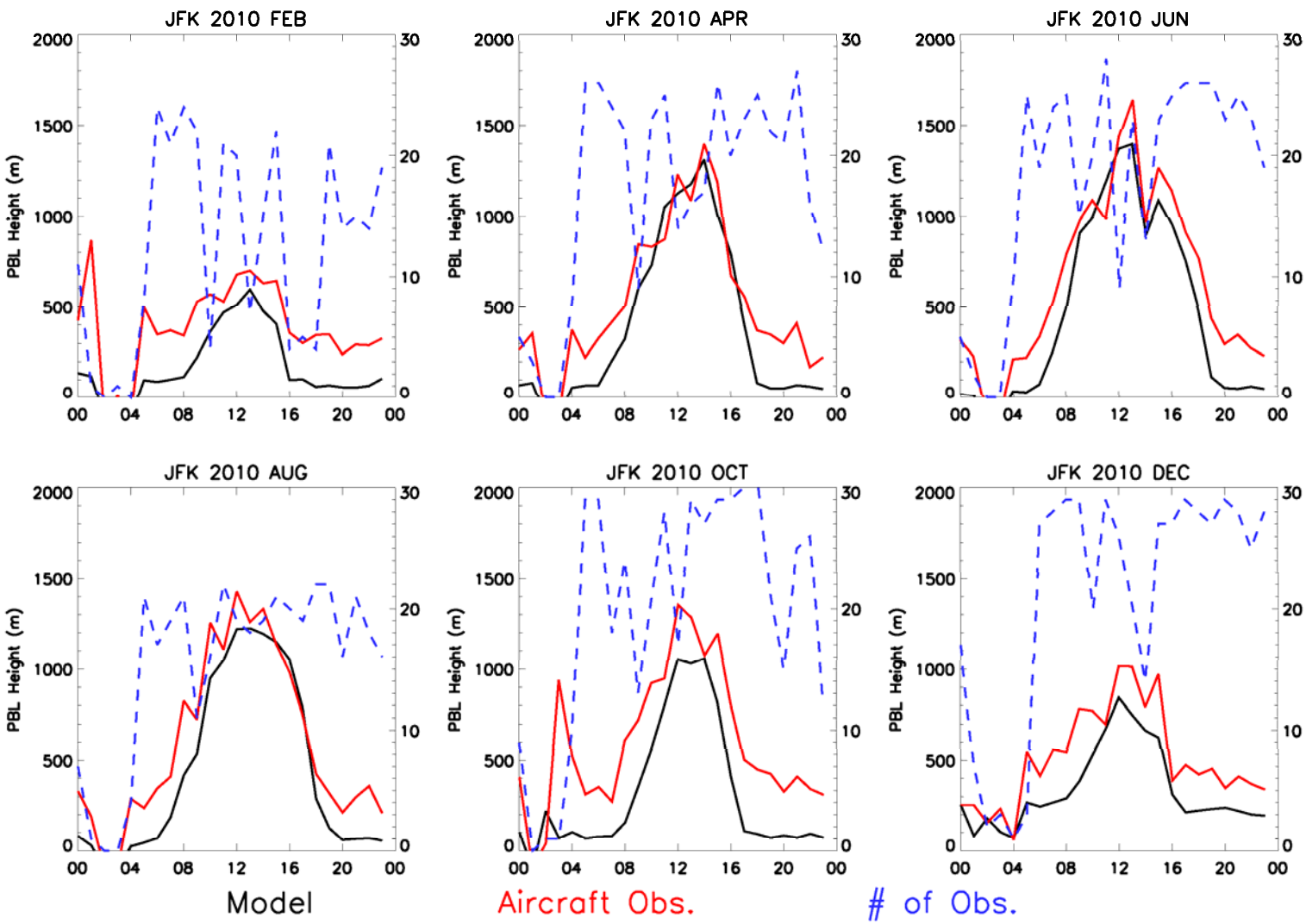
Daily PM2.5 vs AOT at 4 co-located sites:

-- New York City, Fresno, CA, Baltimore, MD, Houston, TX.

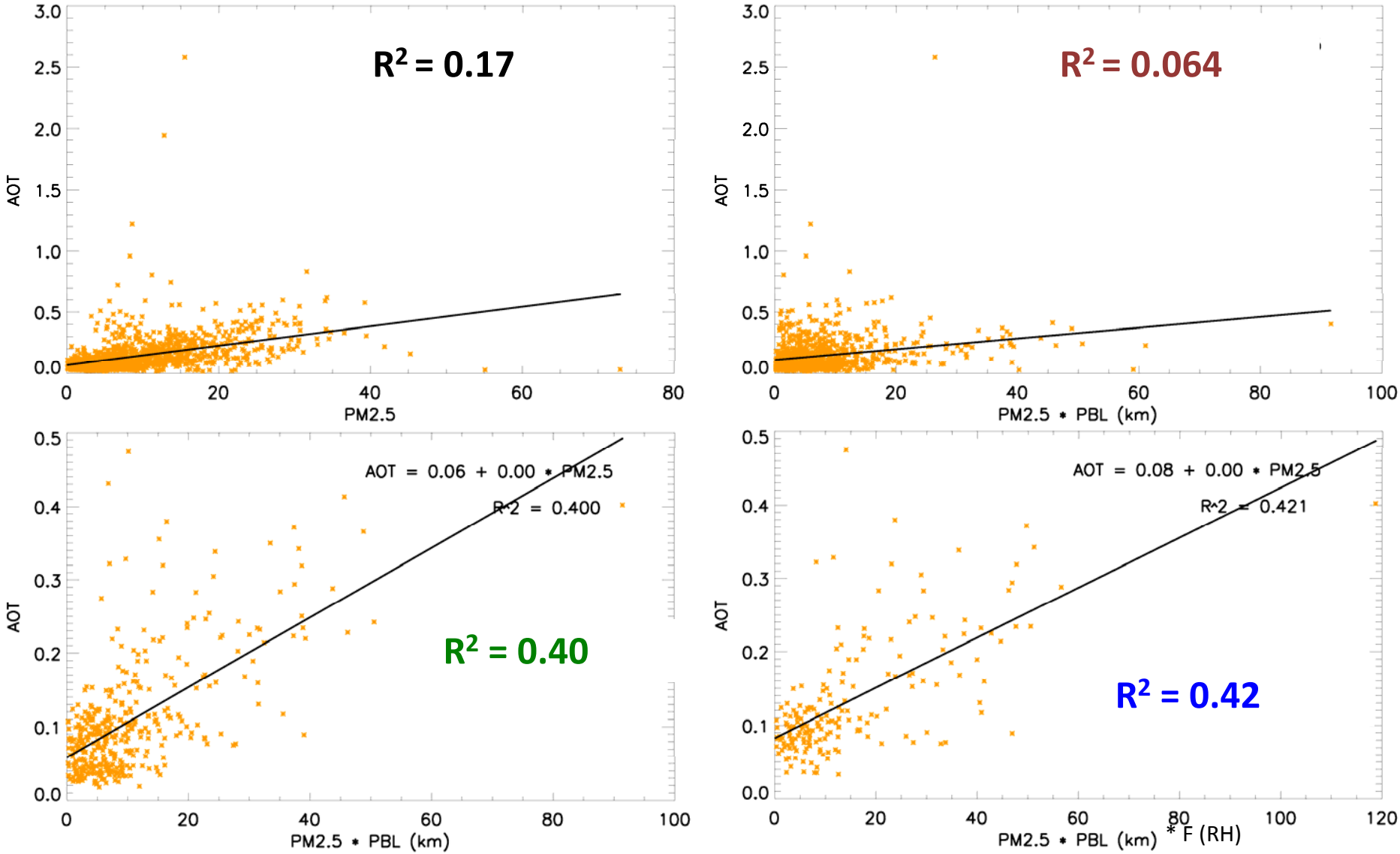
Monthly Averaged Diurnal Cycle of PM2.5 (blue) and AOT (black) at Houston

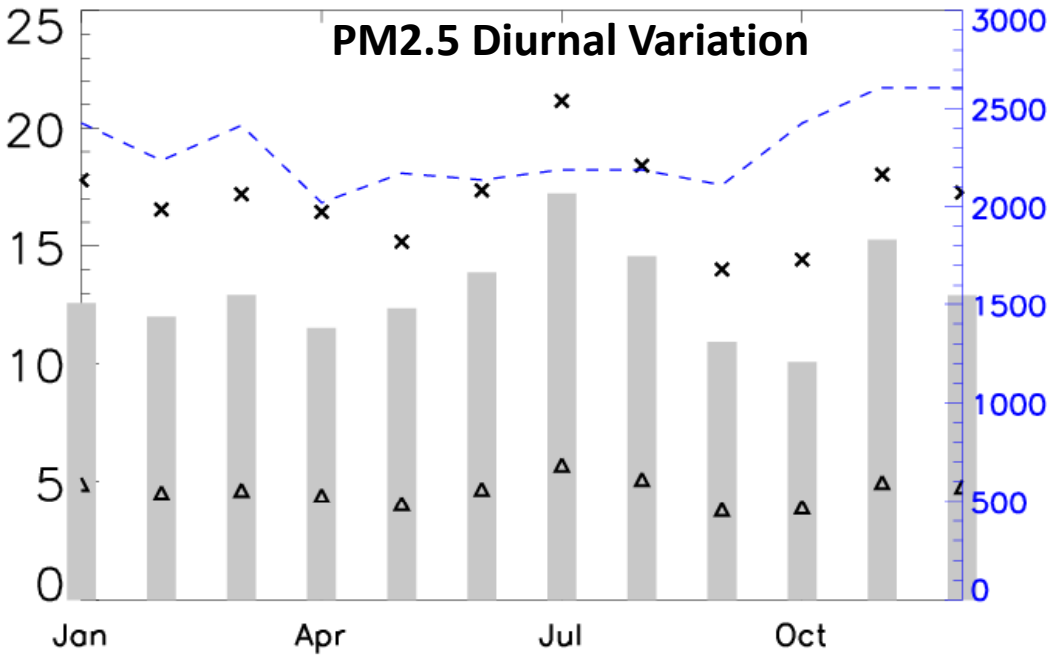


$$AOD = PM2.5 * H * f(RH) * \frac{3Q_{ext/dry}}{4\rho r_{eff}} = PM2.5 * H * S$$

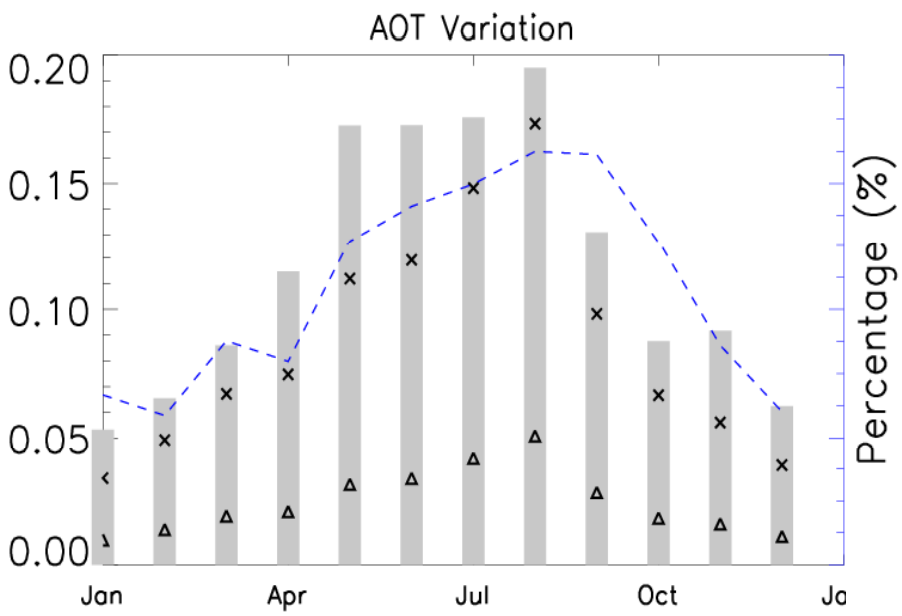


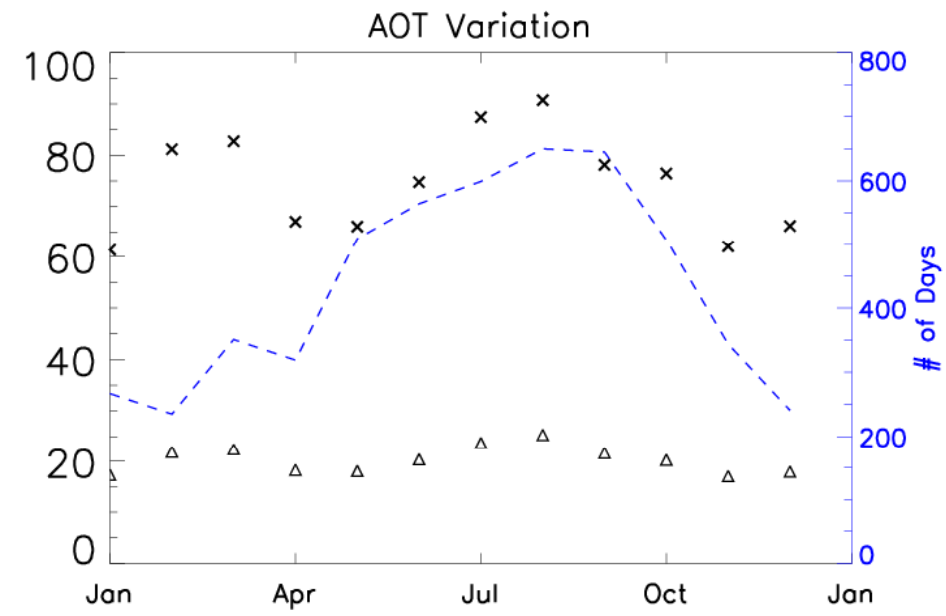
AOT : PM2.5; PM2.5*PBL; PM2.5 * PBL (PBL>1000m); PBL*f(RH) (PBL>1000m)





	Max – Min	(Max - Min) /Mean	STD
PM2.5	14-21 ug/m^3	120-180%	5 ug/m^3
AOT	0.04-0.17	60-90%	0.01-0.05 (20%)





Hygroscopicity of Urban Aerosols

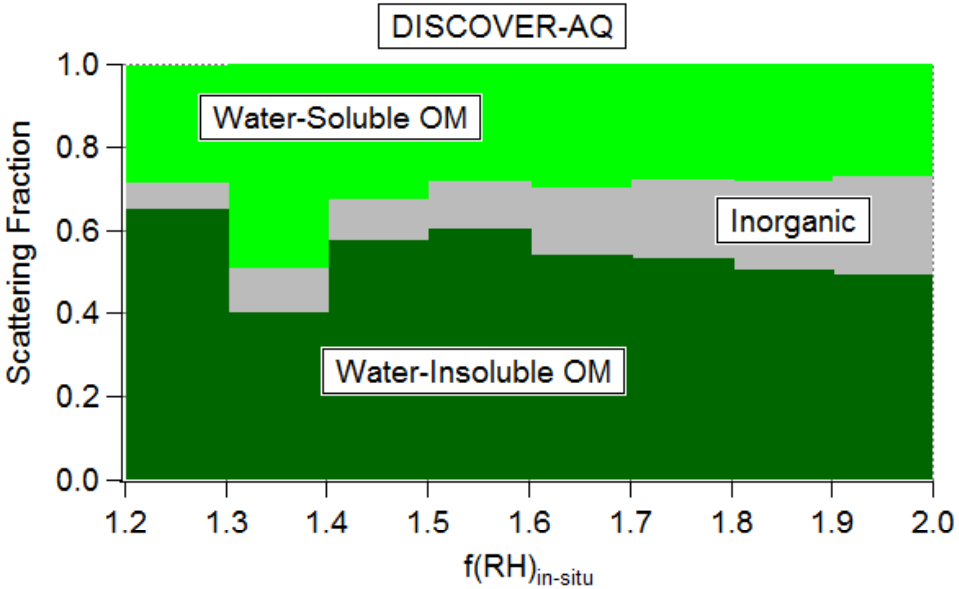
<u>Why a paper?:</u>

- f(RH) is necessary for model input and interpreting remote sensing products

- data from airborne platforms is scarce

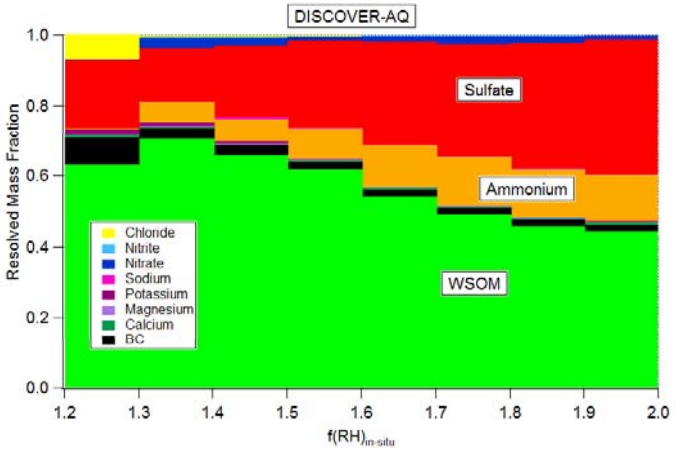
- validation of hygroscopicity model by independent remote sensing!

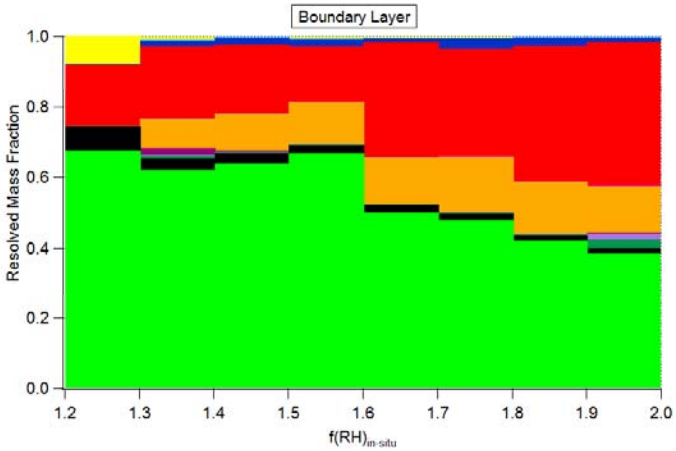
Chemical Dependence

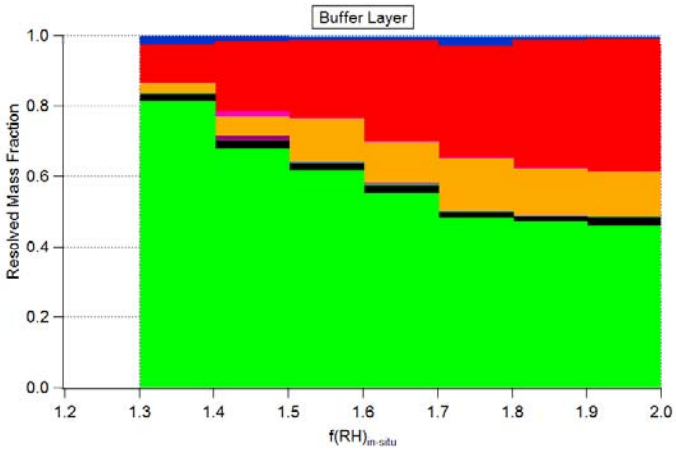


$MSE_{inorganic} = 2.6\ m^2/g$

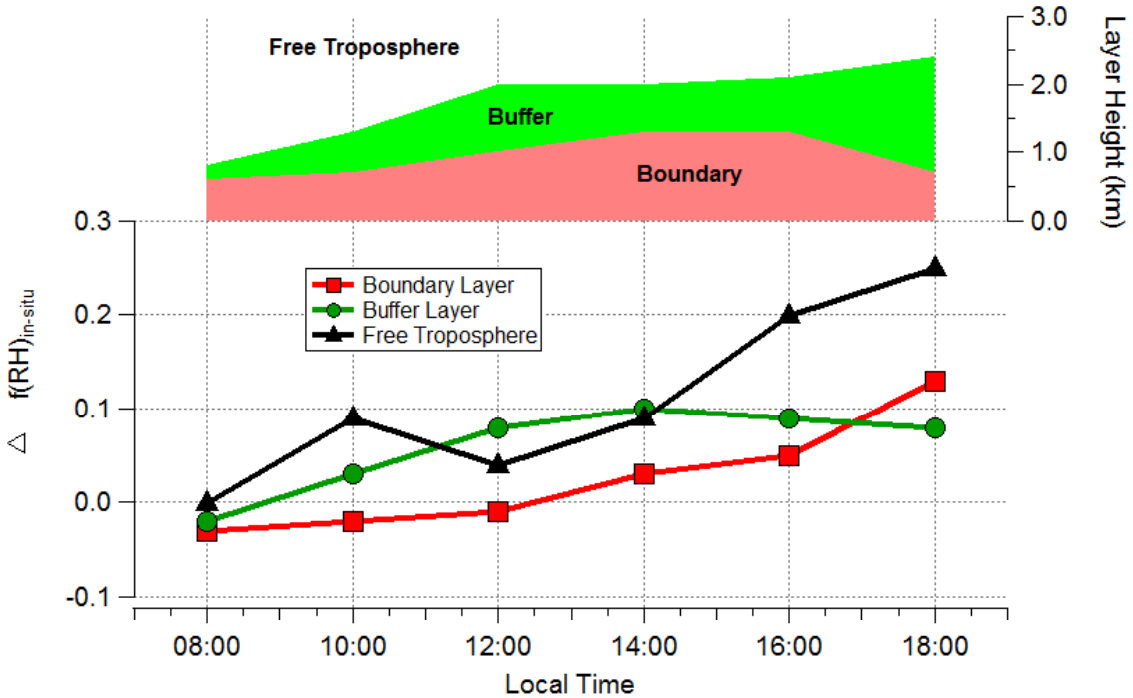
$MSE_{WSOC} = 3.9\ m^2/g$

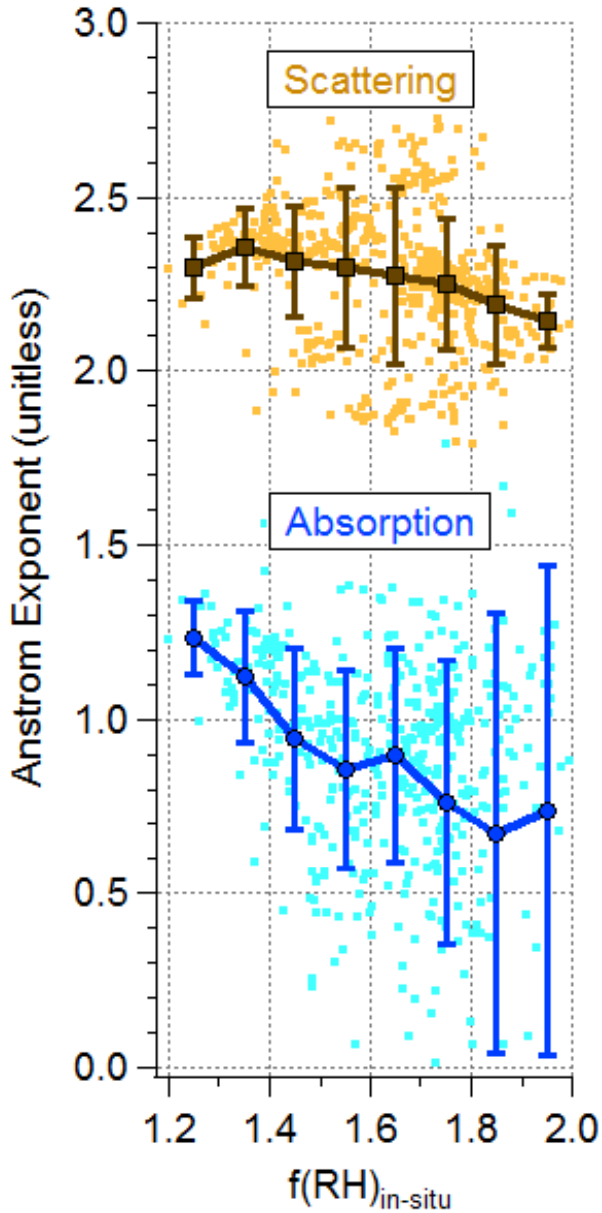




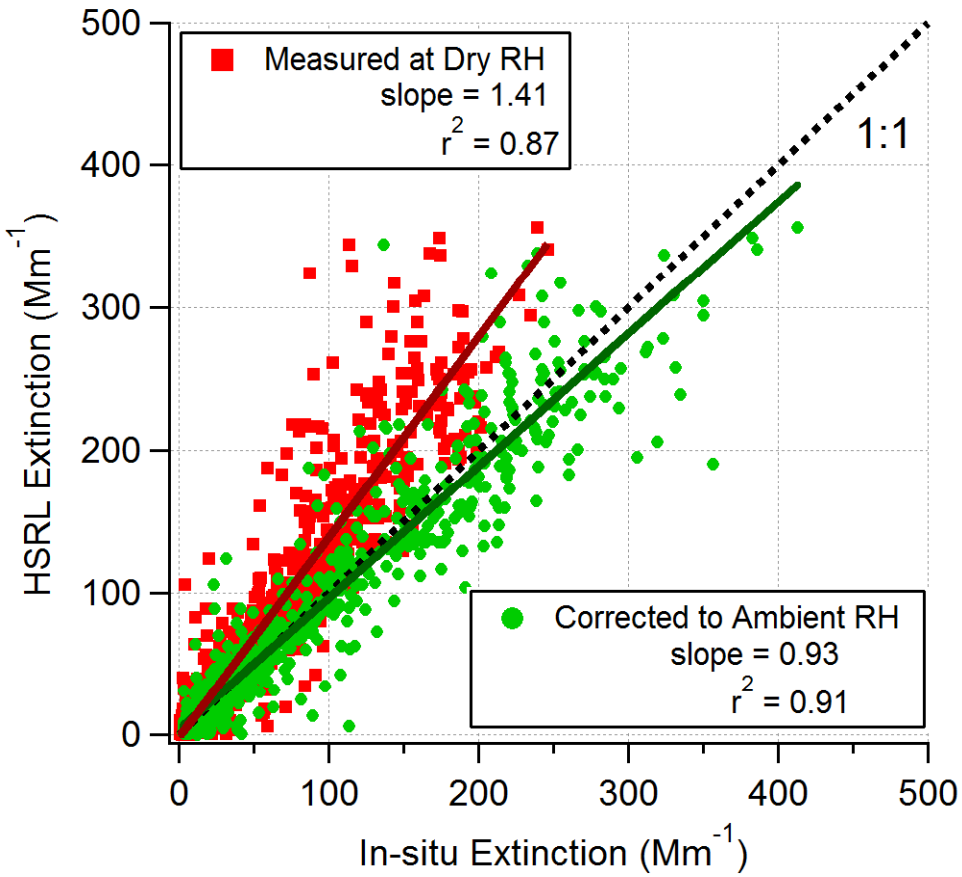


Photochemical Processing
+
Size Dependence

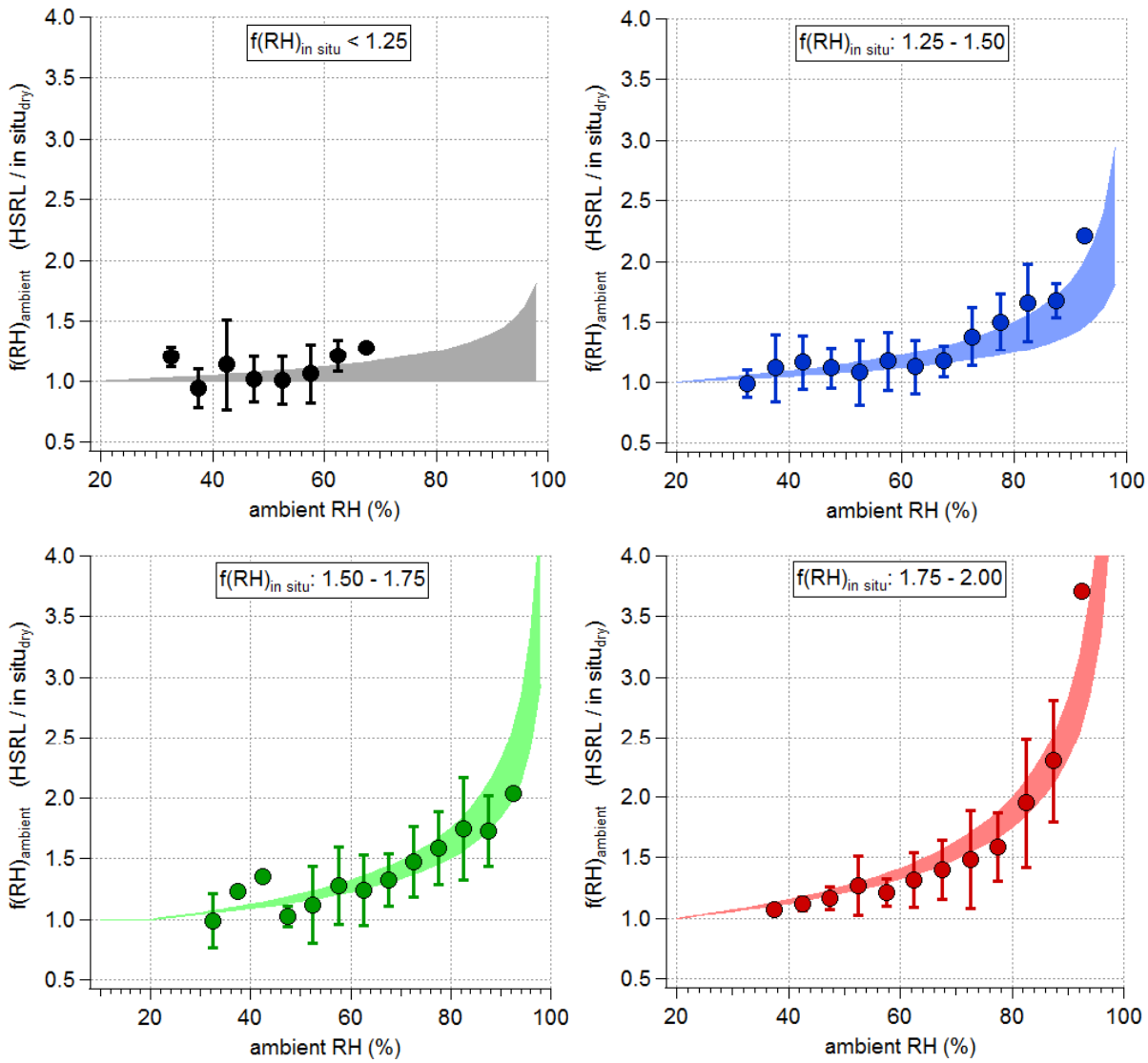




Remote Sensing Validation

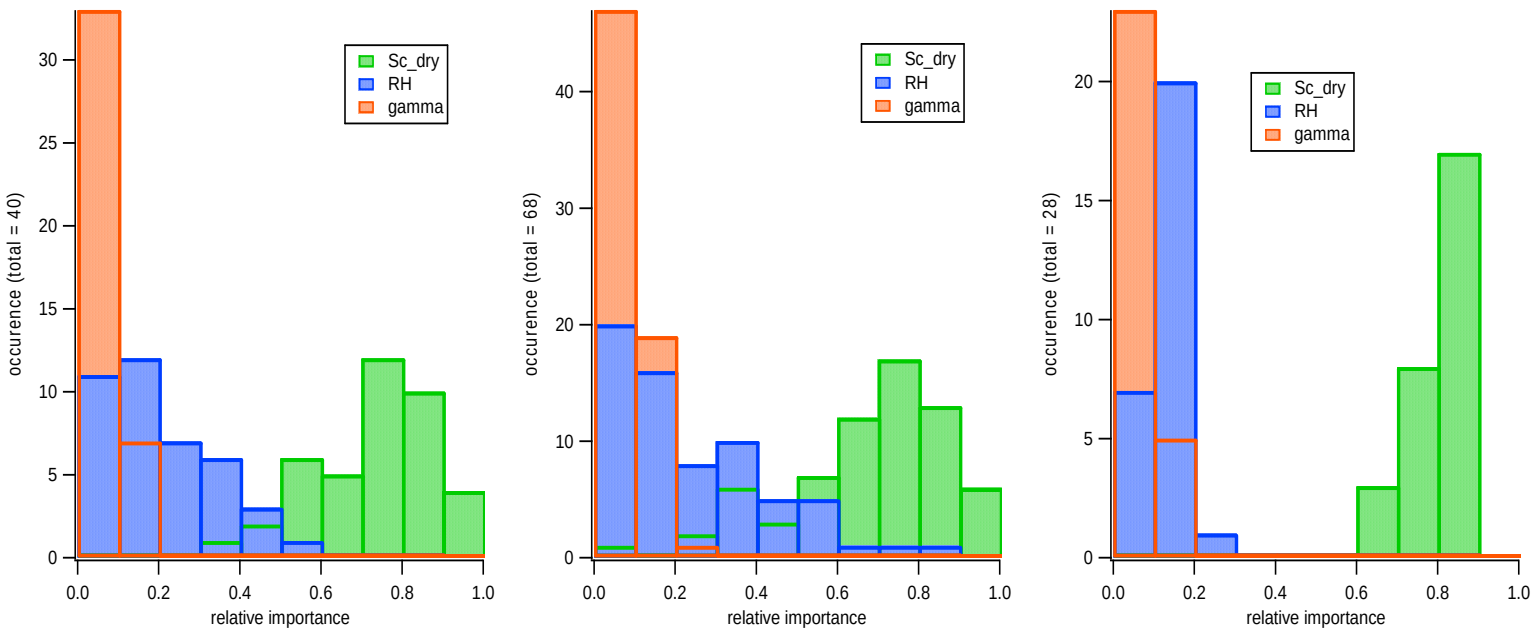


Remote Sensing Validation



Variability Analysis

	Spatial	Diurnal	Temporal
σ_{scat}	72 %	68 %	80 %
RH	20 %	24 %	12 %
γ	7 %	8 %	8 %



Collaboration/Future:

- link to ground sites?
- Aging metric from gas-phase?
- Mie theory calculation of RI?
- Evaluation of assumptions of current models