UPDATES ON THE INTERNATIONAL COOPERATIVE FOR AEROSOL RESEARCH MULTI-MODEL ENSEMBLE (ICAP-MME)

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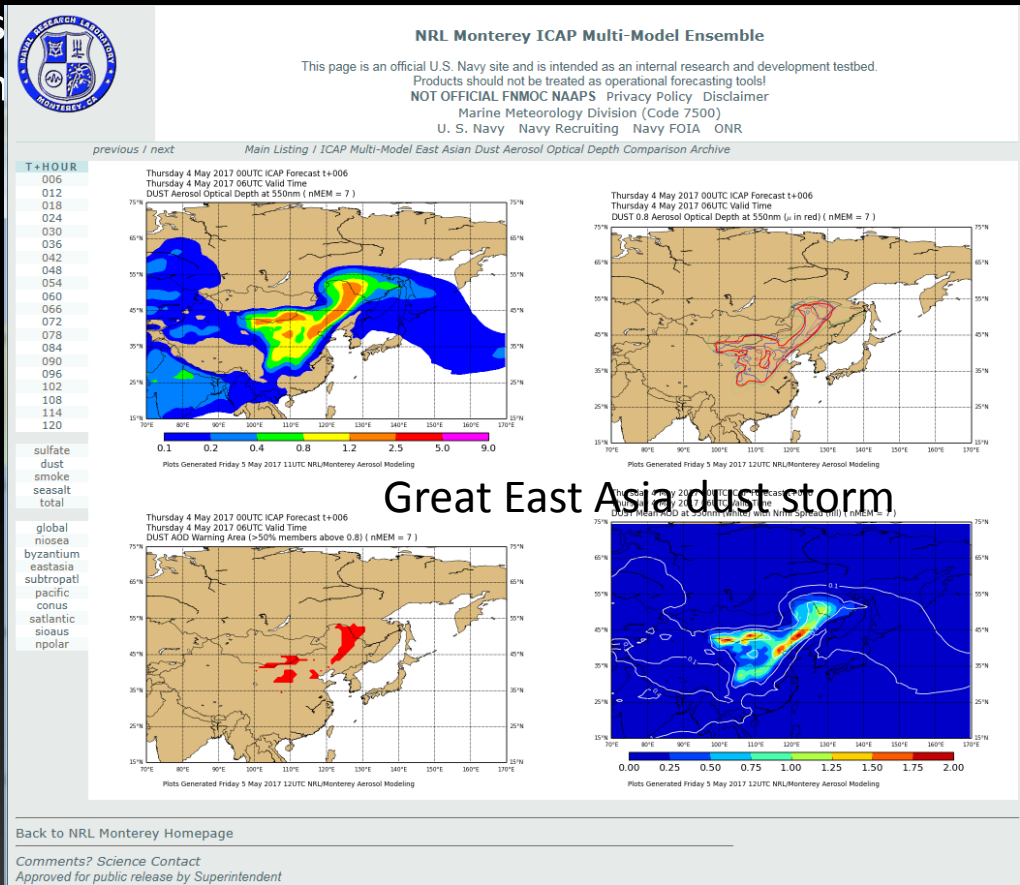
RATIONAL FOR ICAP MME

- It provides a testbed of probabilistic aerosol forecast. Ensemble-based NWP and other atmospheric features (e.g. tropical cyclone) predictions are shown to be able to help control for forecast errors. What about aerosol conditions, e.g., AOT and aerosol concentration?

- Operational aerosol forecast becomes available at many NWP centers, which enables an exploration of aerosol MME.
- It helps to identify problem areas for aerosol modeling.
- It forges valuable collaborations among forecast centers.
- ICAP MME has been the top performer among all models.
- It provides reliable forecast guidance and serves as a good reference dataset (e.g. TIGGE NWP)

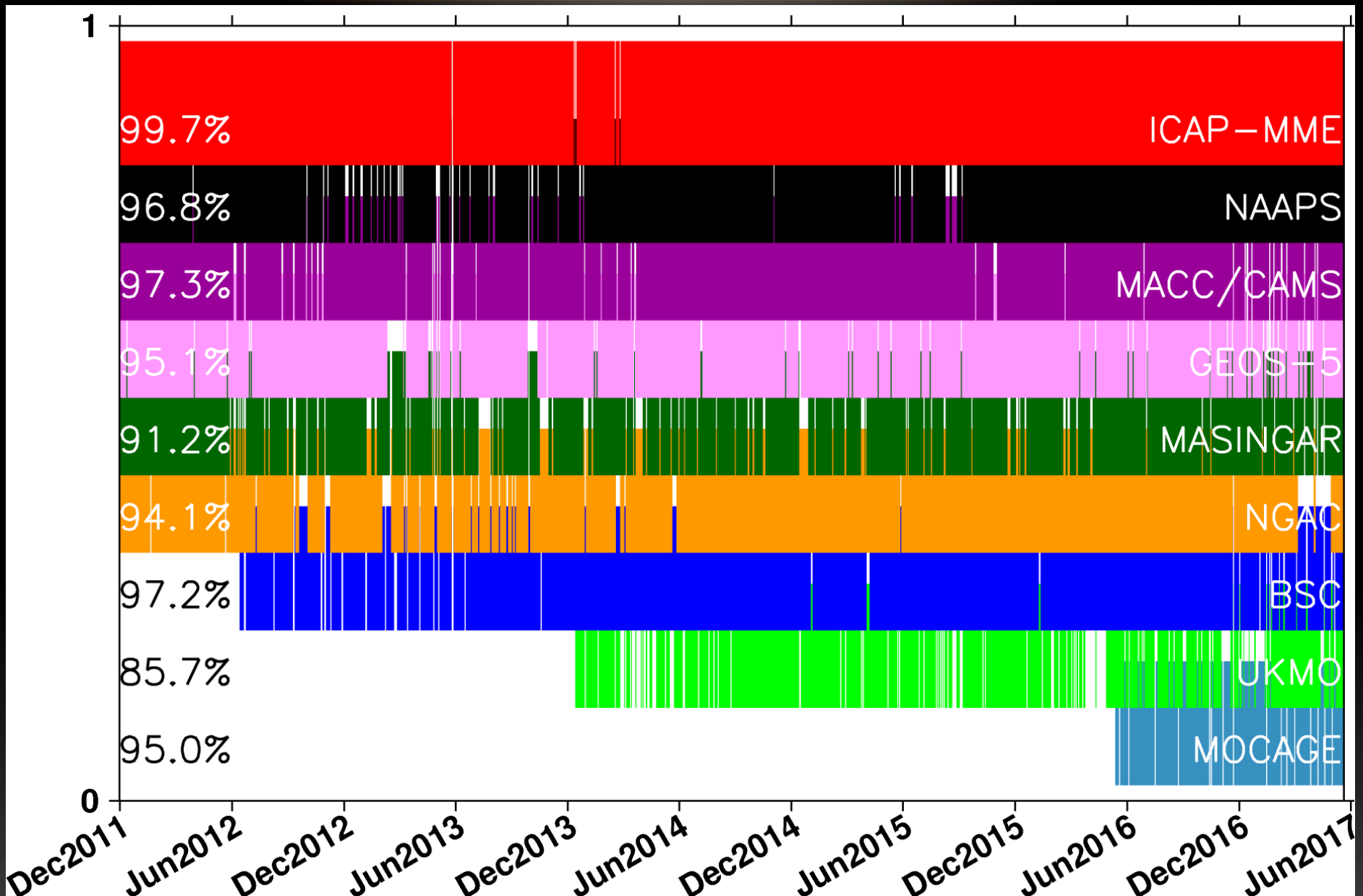


CURRENT ICAP OPERATIONS-AS OF JUNE 2017

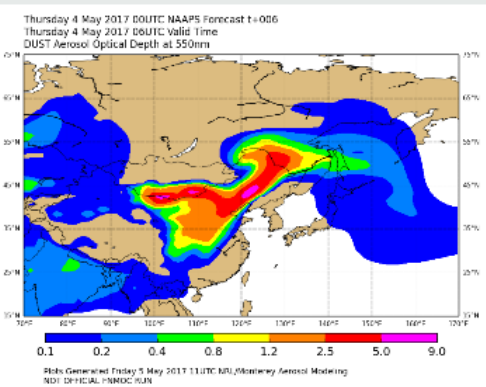
Organization	BSC	Copernicus/ ECMWF	JMA	Meteo France	NASA	US Navy	NOAA	UKMO
Model	NMMB/BSC-CTM MONARCH	~~MACC~~ CAMS	MASINGAR	MOCAGE	GEOS-5	NAAPS	NGAC	MetUM
Status	QO	O-24 hrs	QO	O	QO	O	O	O
Meteorology	Inline NMMB	Inline IFS	inline AGCM	Offline ARPEGE	Inline GEOS-5	Offline NAVGEM	Inline GFS	Inline UM
Resolution	1.4x1 (0.7x0.5)	0.4x0.4	~~0.56x0.56~~ 0.375x0.375	~~2x2~~ 1x1	~~0.25x0.31~~ 0.125x0.125 (Cube)	0.33x0.33	1x1	~~0.35x0.23~~ 0.23x0.15 (0.14x0.09)
levels	24 (48)	60	40	47	72	60	64	70
DA	LETKF^{p}	4DVar	2DVar LETKF^{p}	2018	2DVar +LDE	2DVar 3DVar, EnKF^{p}	NA	4DVar
Assimilated Obs	DAQ MODIS+DB	DAQ MODIS+DB	MODIS, Himawari-8^{p}, CALIOP^{p}	NA	Neural Net MODIS	DAQ MODIS, AVHRR^{p} VIIRS^{p} CALIOP^{p}	NA	MODIS Dust AOT
Species	Dust Sea Salt BC, OC (POA,SOA) Sulfate	BC, OC Dust Sea Salt Sulfate	BC, OC Dust Sea Salt Sulfate	BC, OC Dust Sea Salt Sulfate	BC, OC Dust Sea Salt Sulfate Nitrate	Anthro+bio B. Burn Dust Sea Salt	Dust BC, OC Sea Salt Sulfate	Dust
Size Bins	8 (dust, salt) Bulk (BC, OC, Su)	3	10 (dust, salt), Bulk (BC, OC, Su)	6	5	1	5	2
Bio. Burn. Emissions	GFAS	GFAS	GFAS	GFAS	QFED	FLAMBE	GBBEPx	NA

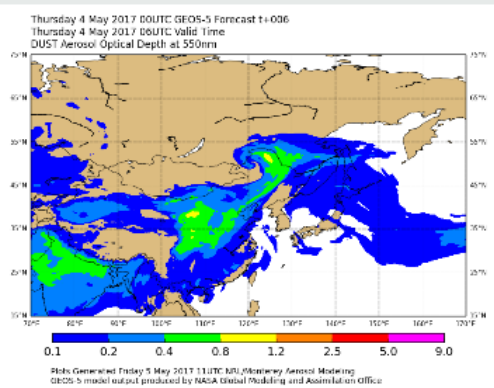
- The ICAP-MME is run daily w/ 1x1 deg res at 00Z for 6 hrly fcasts out to 120 hrs w/ a 1-day latency.
- Modal AOT (550nm) and dust AOT (550nm) data in NetCDF is available at http://usgodae.org/cgi-bin/datalist.pl?dset=nrl_icap_mme&summary=Go

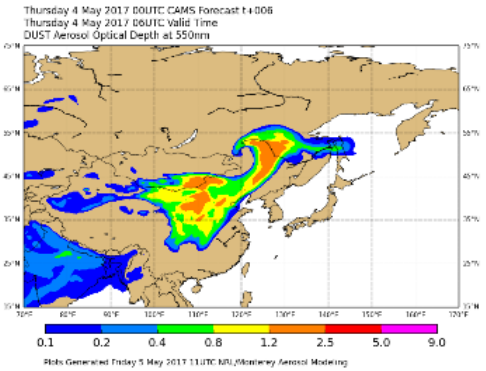
DATA FLOW OF THE ICAP MODELS

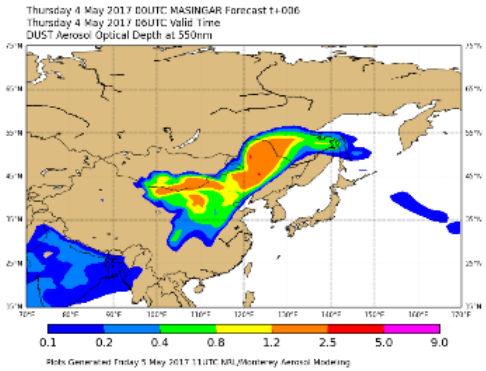


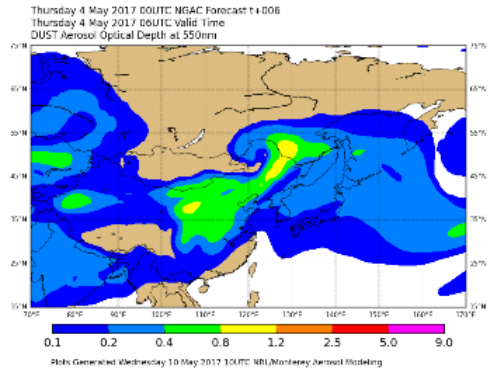
EAST ASIAN DUST CASE: MAY 4, 2017
INDIVIDUAL MODELS

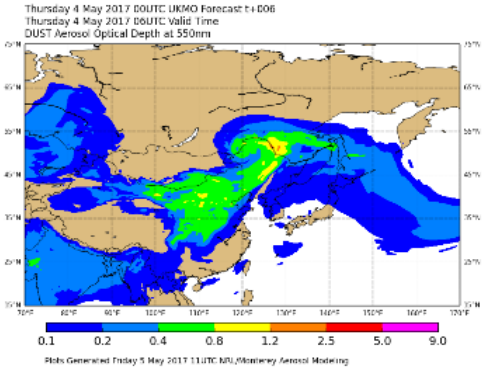


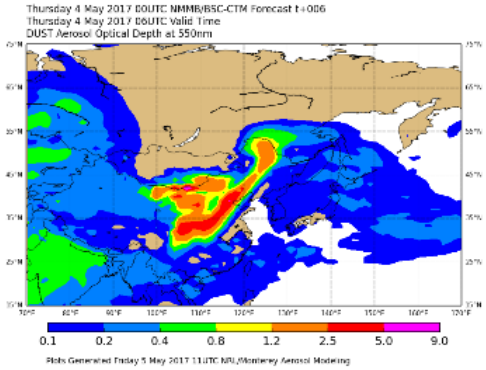


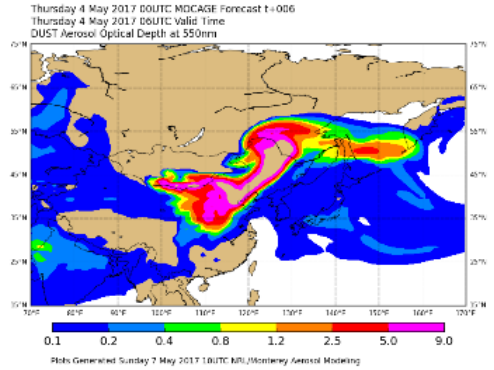




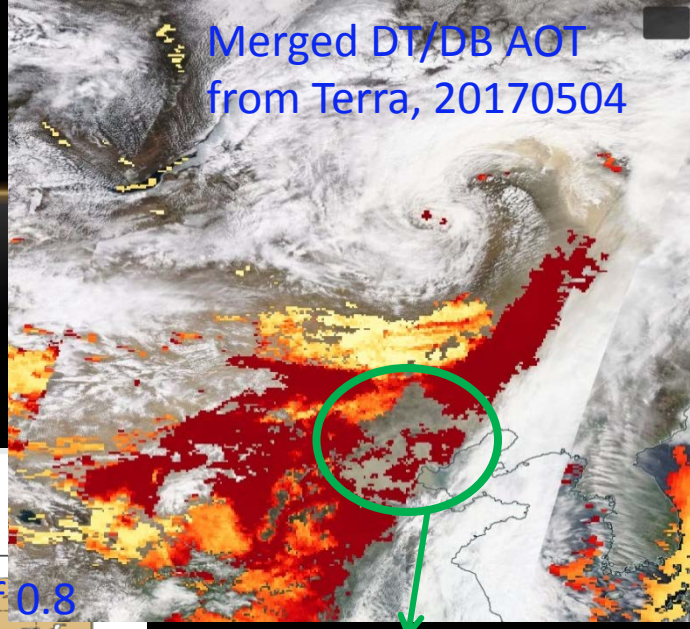




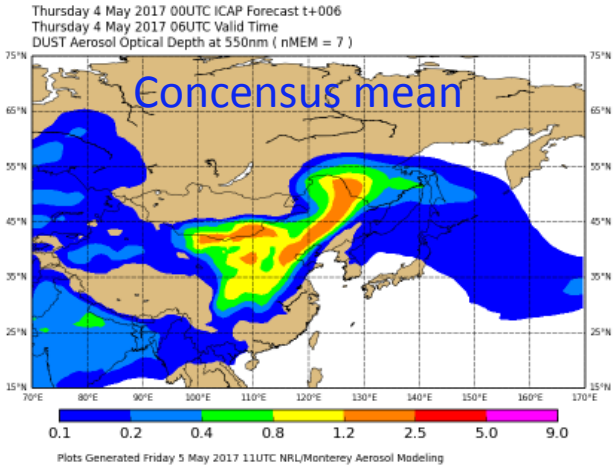


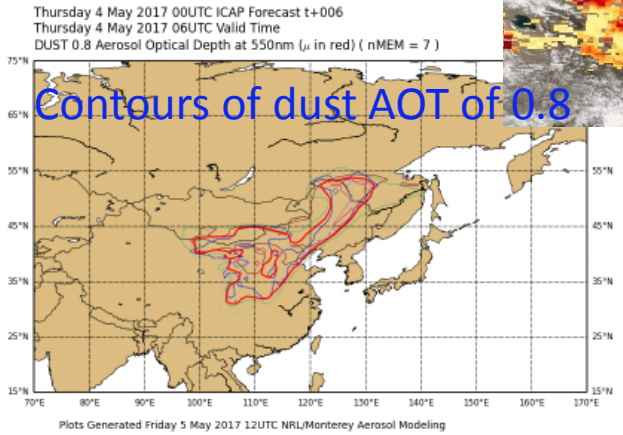


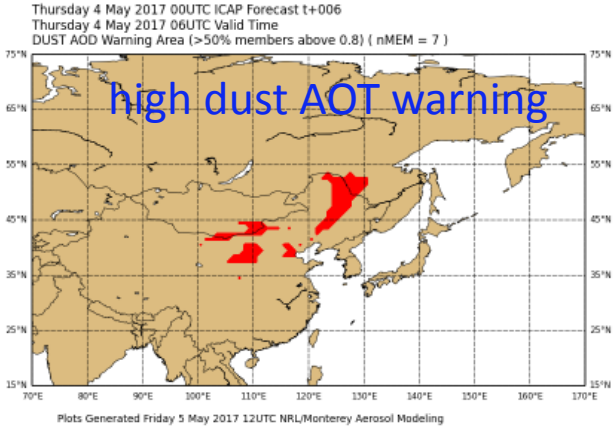
THE EAST ASIAN DUST CASE
ICAP MME

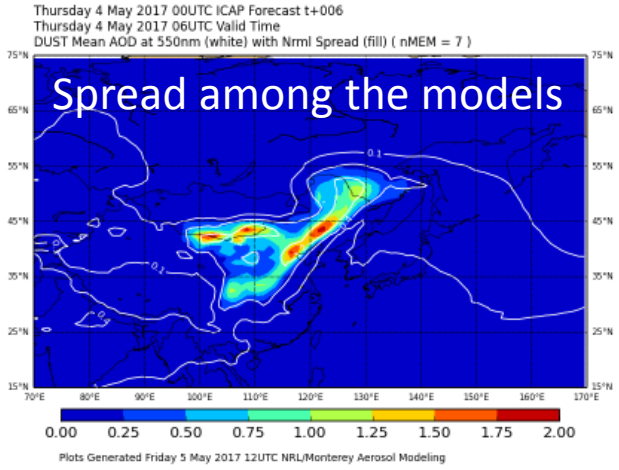


AOT too high for MODIS DT /DeepBlue to retrieve.

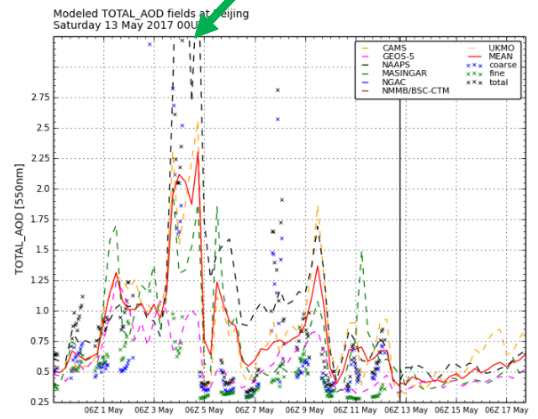




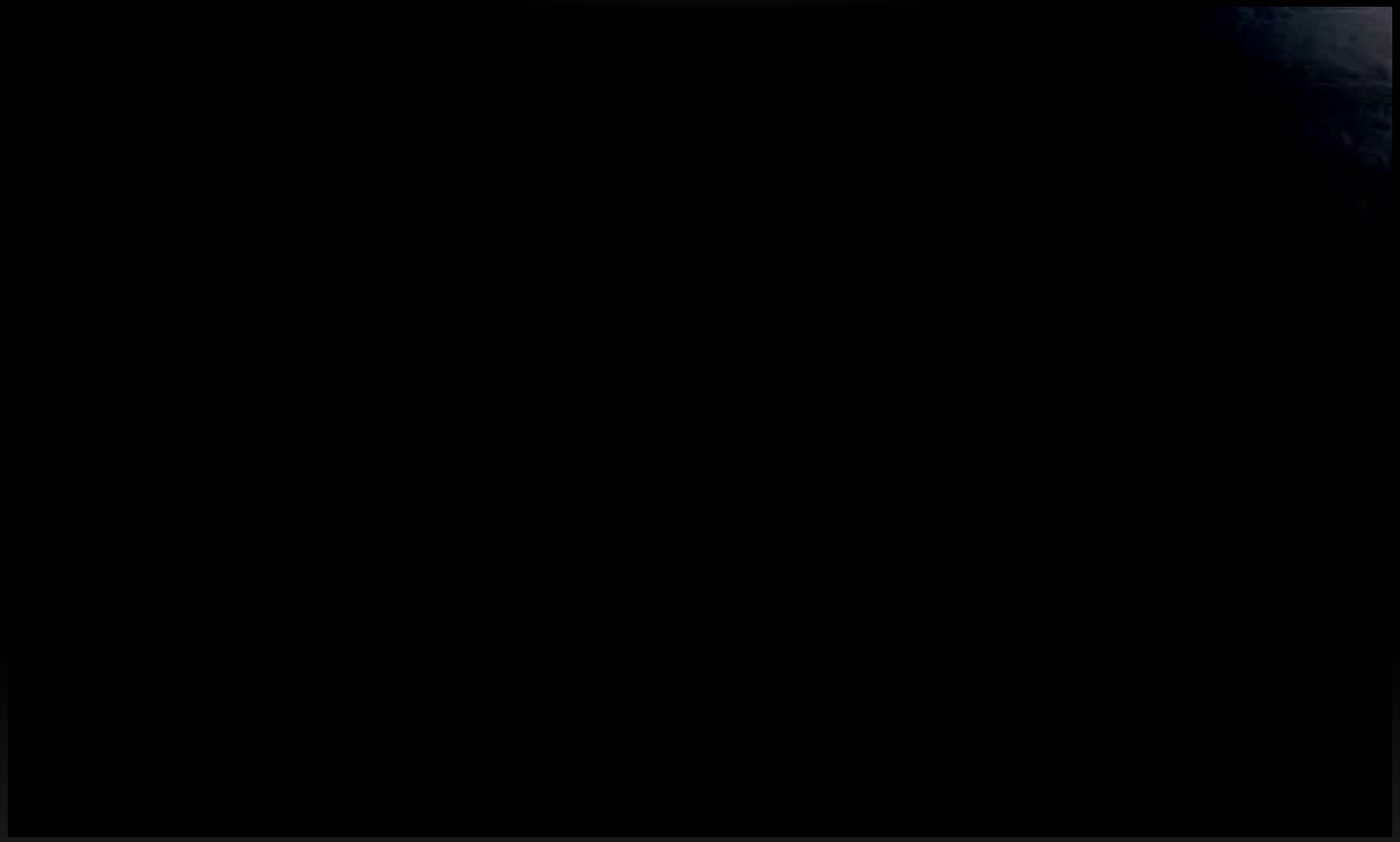




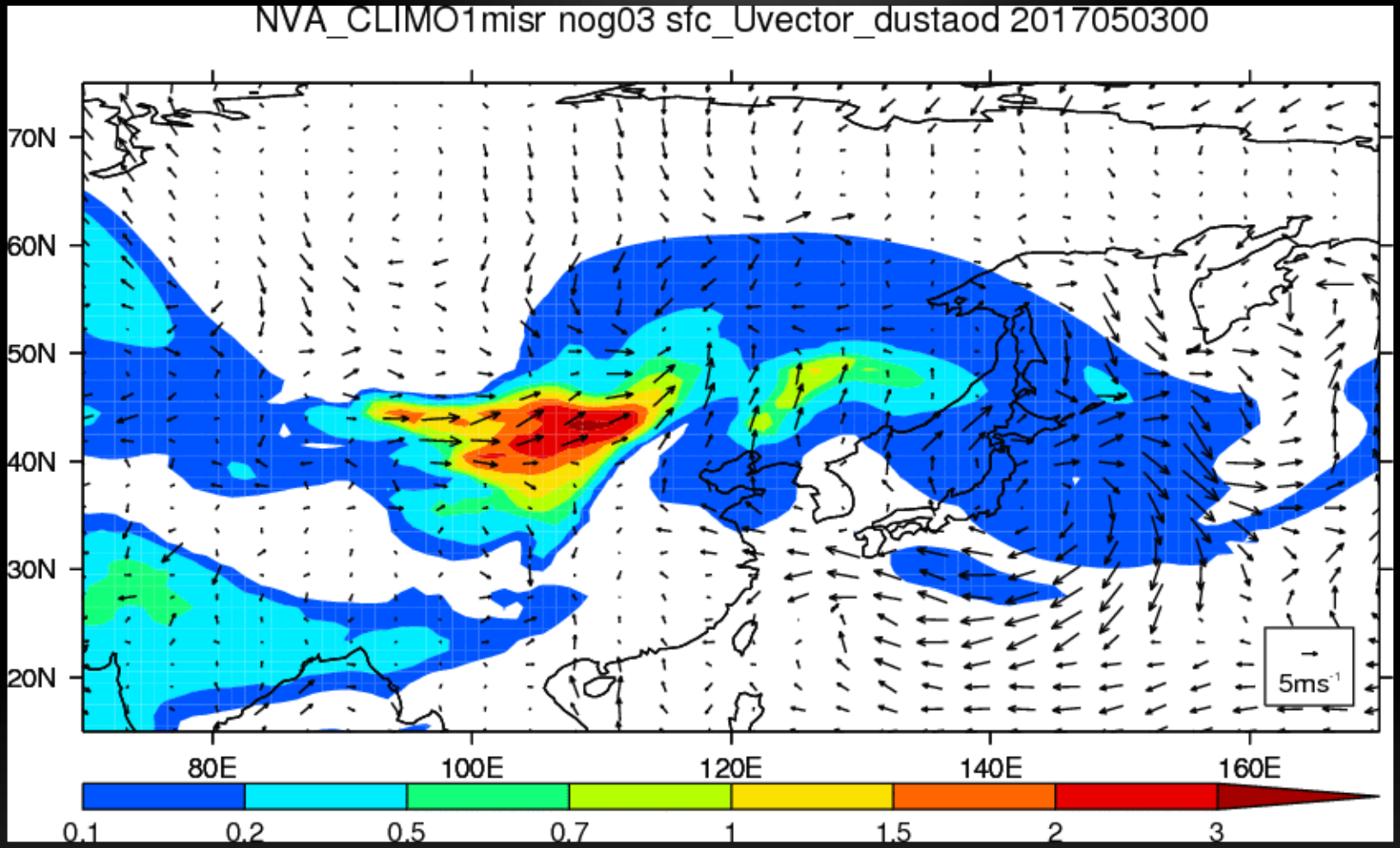
AERONET AOT at Beijing >3.0



DUST EVOLUTION SEEN BY GEO-STATIONARY HIMAWARI-8 (MAY 3-5, 2017)



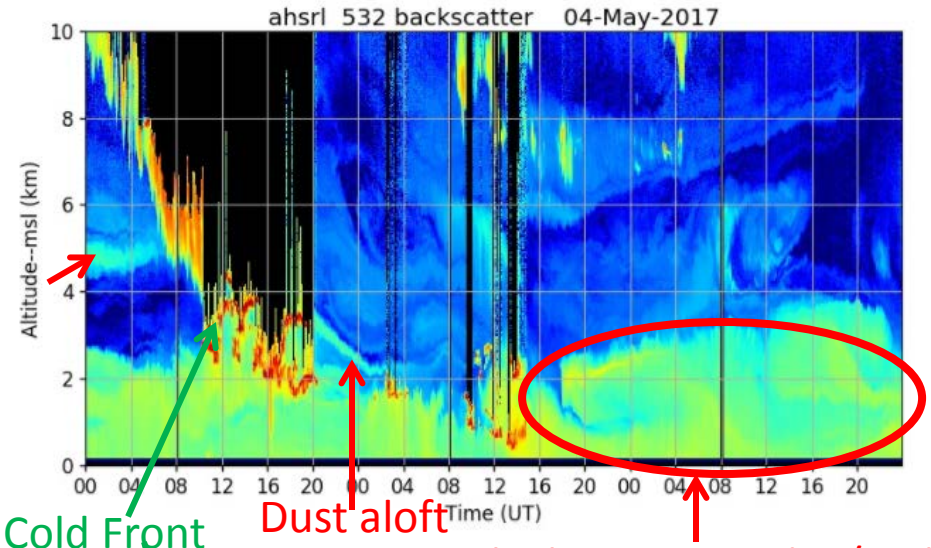
DUST EVOLUTION IN ICAP NAAPS



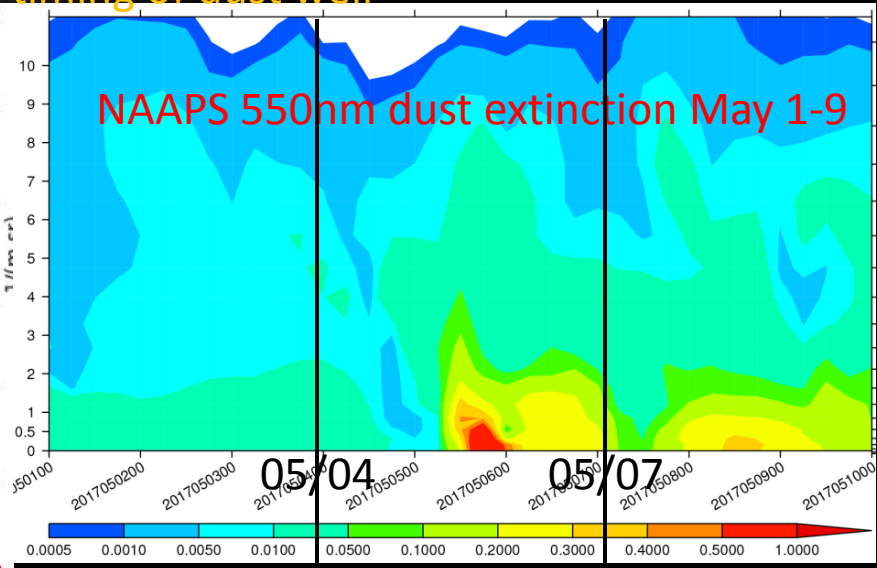
AEROSOL VERTICAL PROFILES AT SEOUL FOR THE DUST CASE

THANKS TO U. OF WISCONSIN LIDAR GROUP

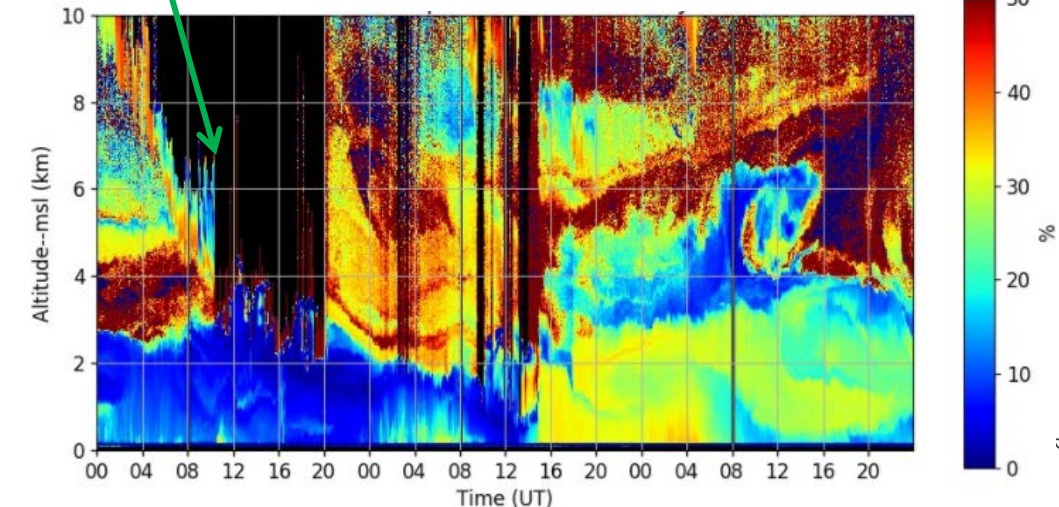
HSRL 532 back scatter May 4-6, 2017

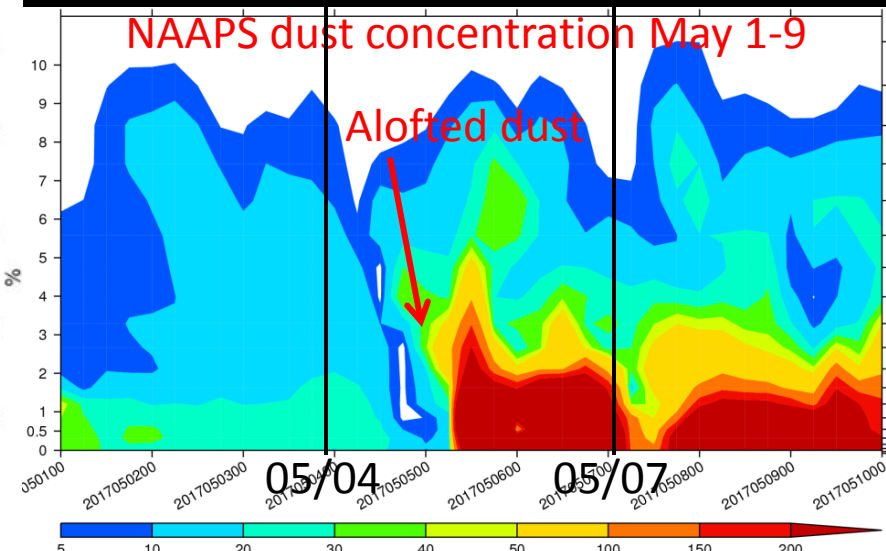


NAAPS captures the vertical distribution and timing of dust well



HSRL depolarization May 4-6, 2017

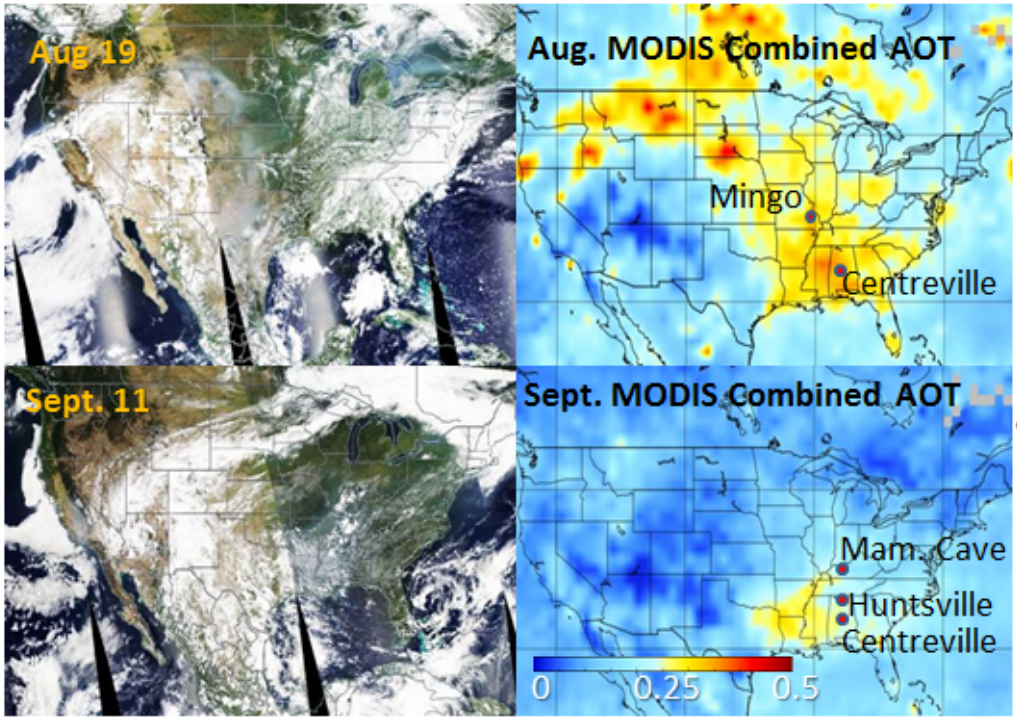


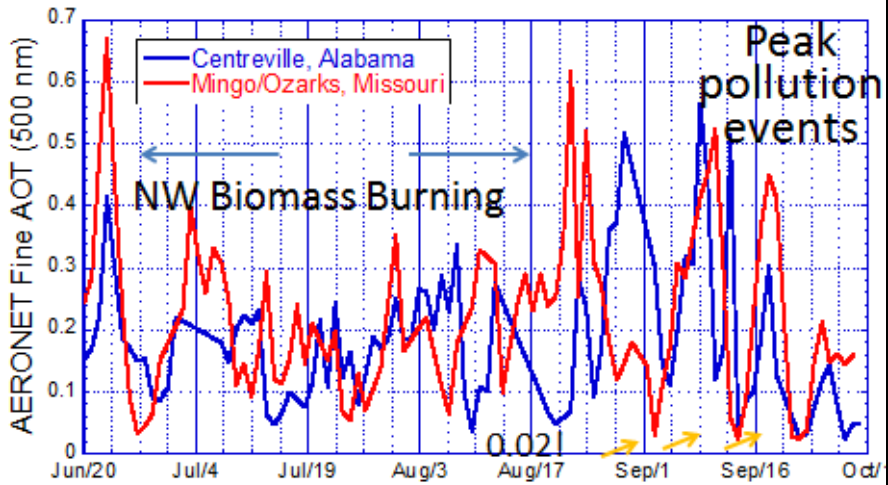


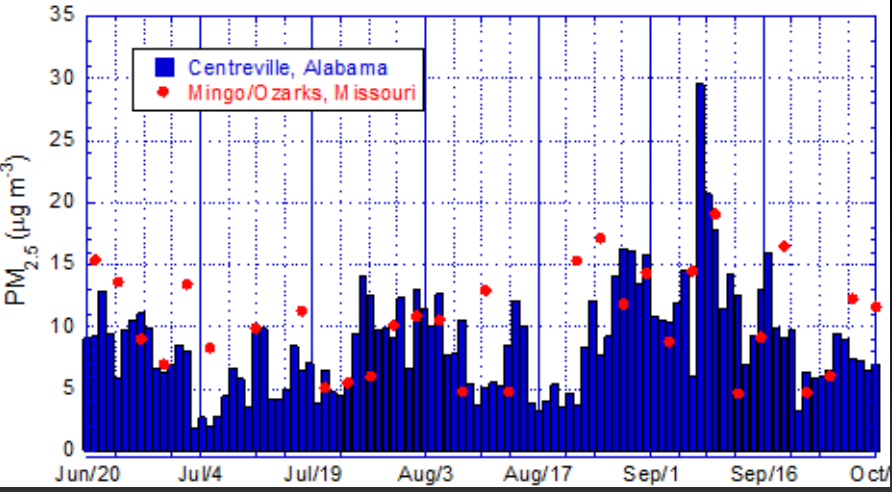
SOUTHEAST U.S. CASES

2013 Regional AOT Fields

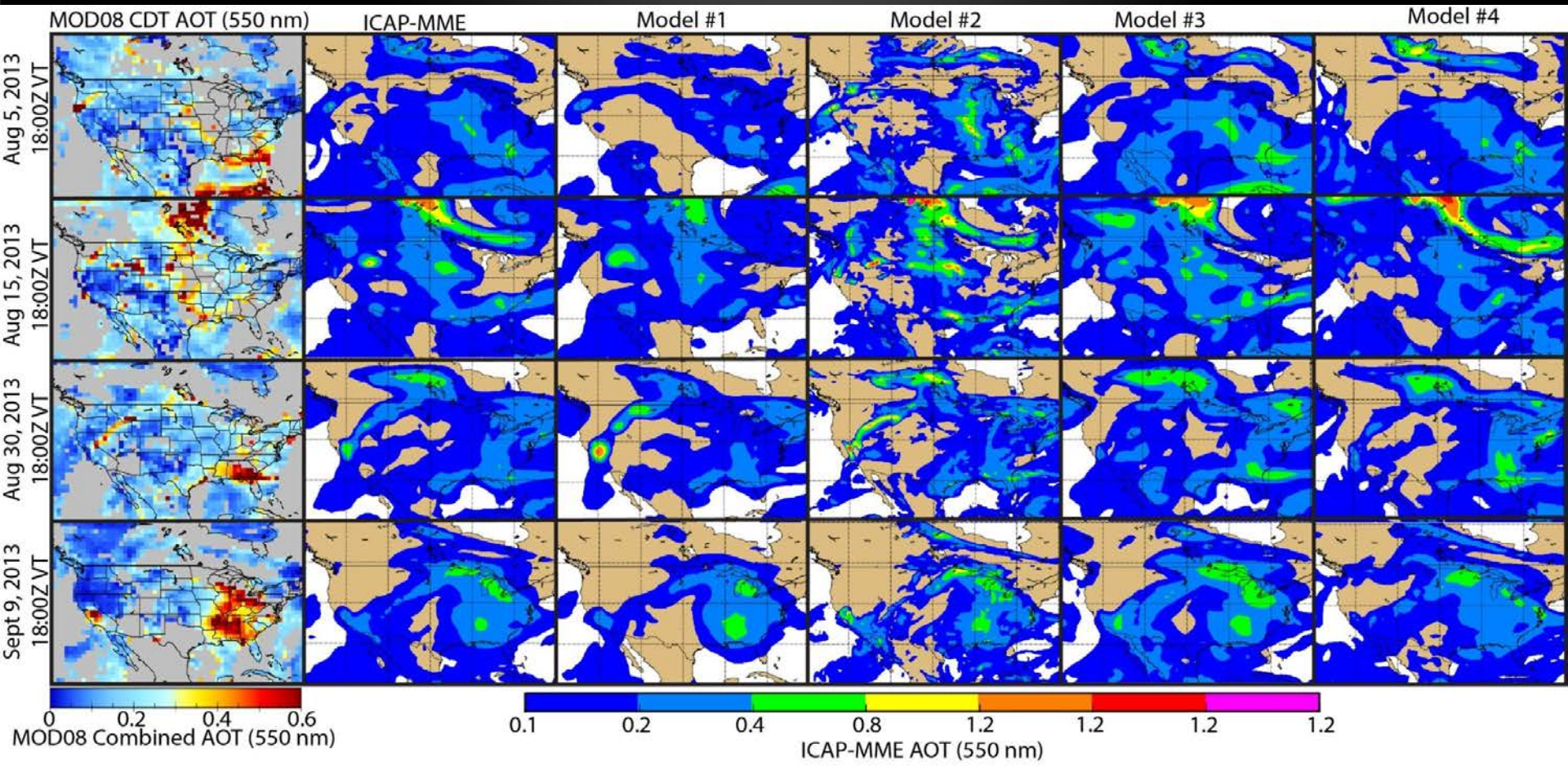
Synopsis: The SEAC4RS mission occurred during a highly active biomass burning year. Consequently, the SEUS was impacted by a combination of regional pollution and transported biomass burning events. Nevertheless, 2013 was a "median year" for PM2.5 and regional AOT.







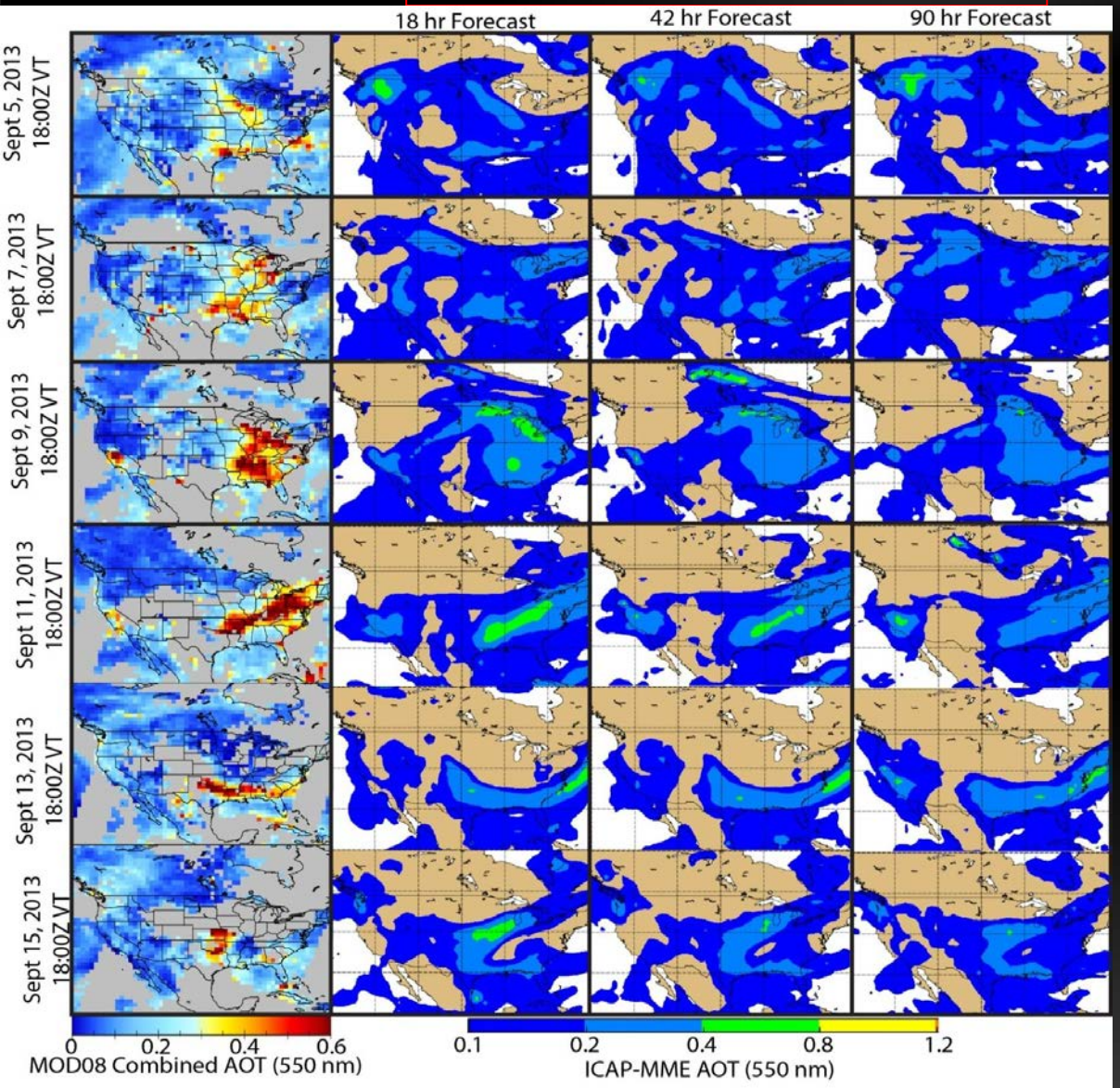
18HR AOT FORECAST FOR SIGNIFICANT EVENTS



All models generally show in their 18hr forecast similar AOT patterns for the largest events during SEAC4RS, including both pollution and biomass burning events. However large differences can be observed, especially as a function of resolution.

ICAP MME AOT AS A FUNCTION OF FORECAST TIME

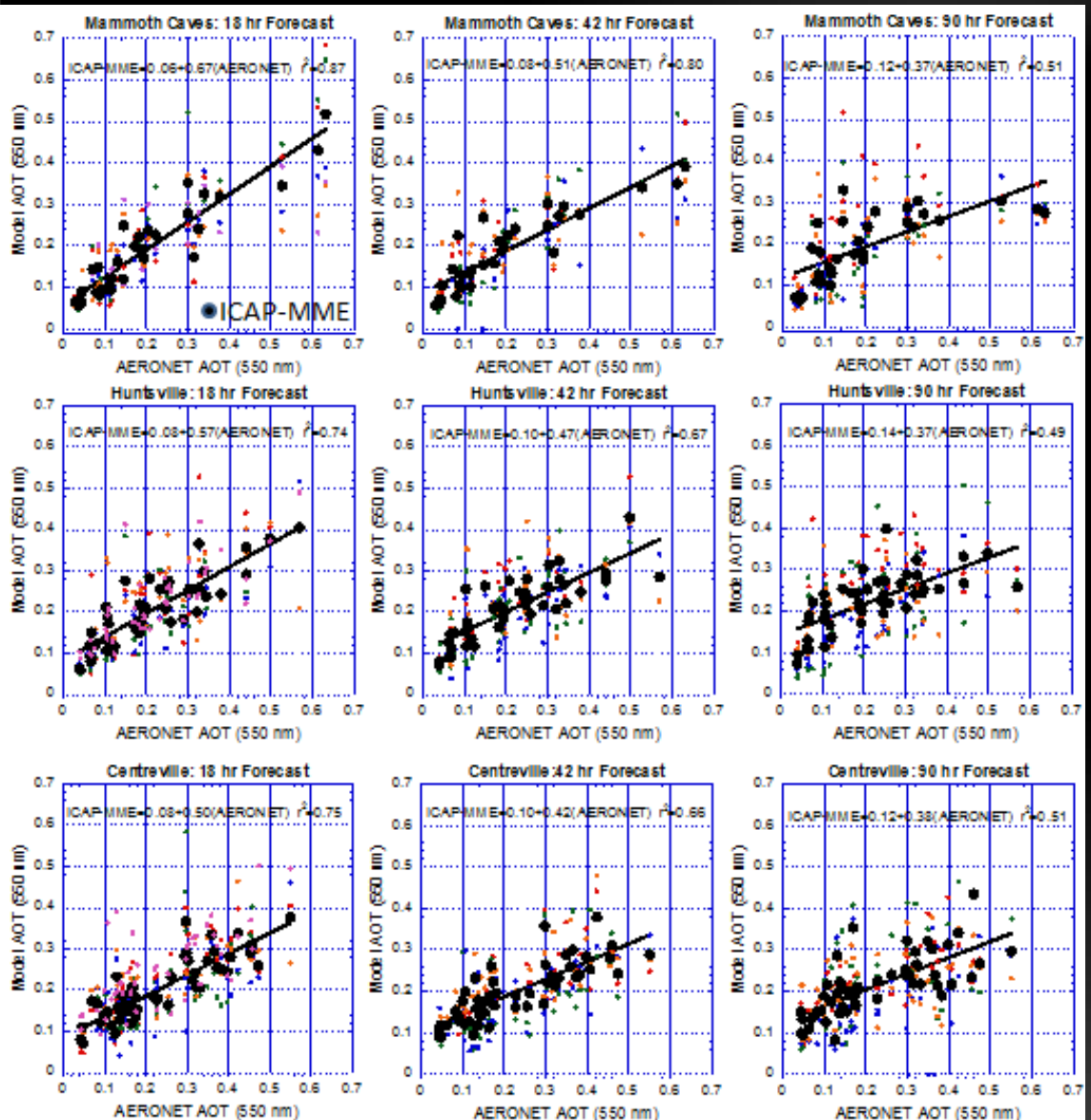
MODIS | 18hr | 42hr | 96hr



ICAP MME captures the AOT distribution and magnitude well. With solid scores out to 4 days. That is because AOT distributions are dominated by synoptic meteorology and transport.

AOT VALIDATION WITH AERONET

Forecasts at 18hr 42hr 90hr



Mammoth Cave

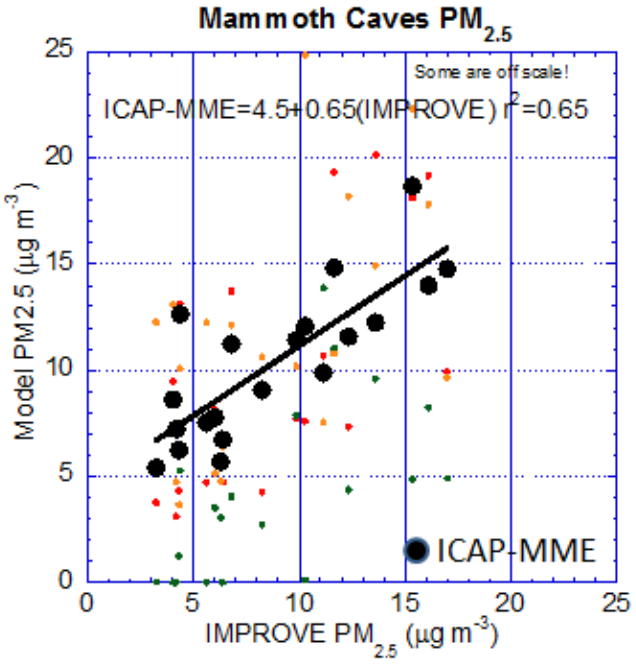
Huntsville

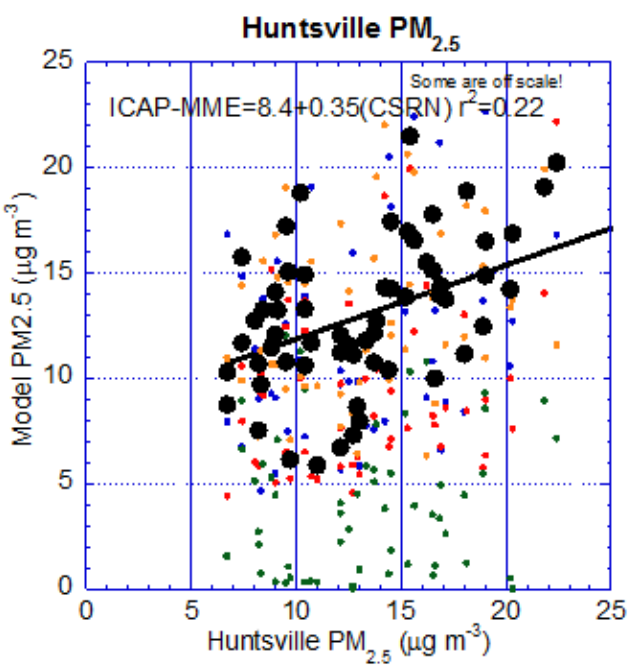
Centreville

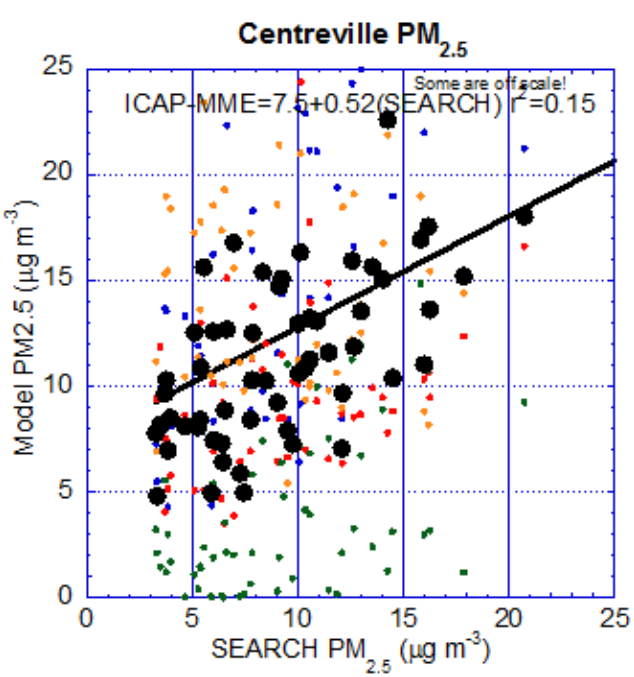
Bold black ICAP-MME. Colored points members.

- Models do well at AOT. With solid scores out to 4 days. That is because AOT distributions are dominated by synoptic meteorology and transport.
- There is stronger bias with forecast time as expected.
- ICAP MME is the top performer among all the models.

18HR $PM_{2.5}$ FORECAST

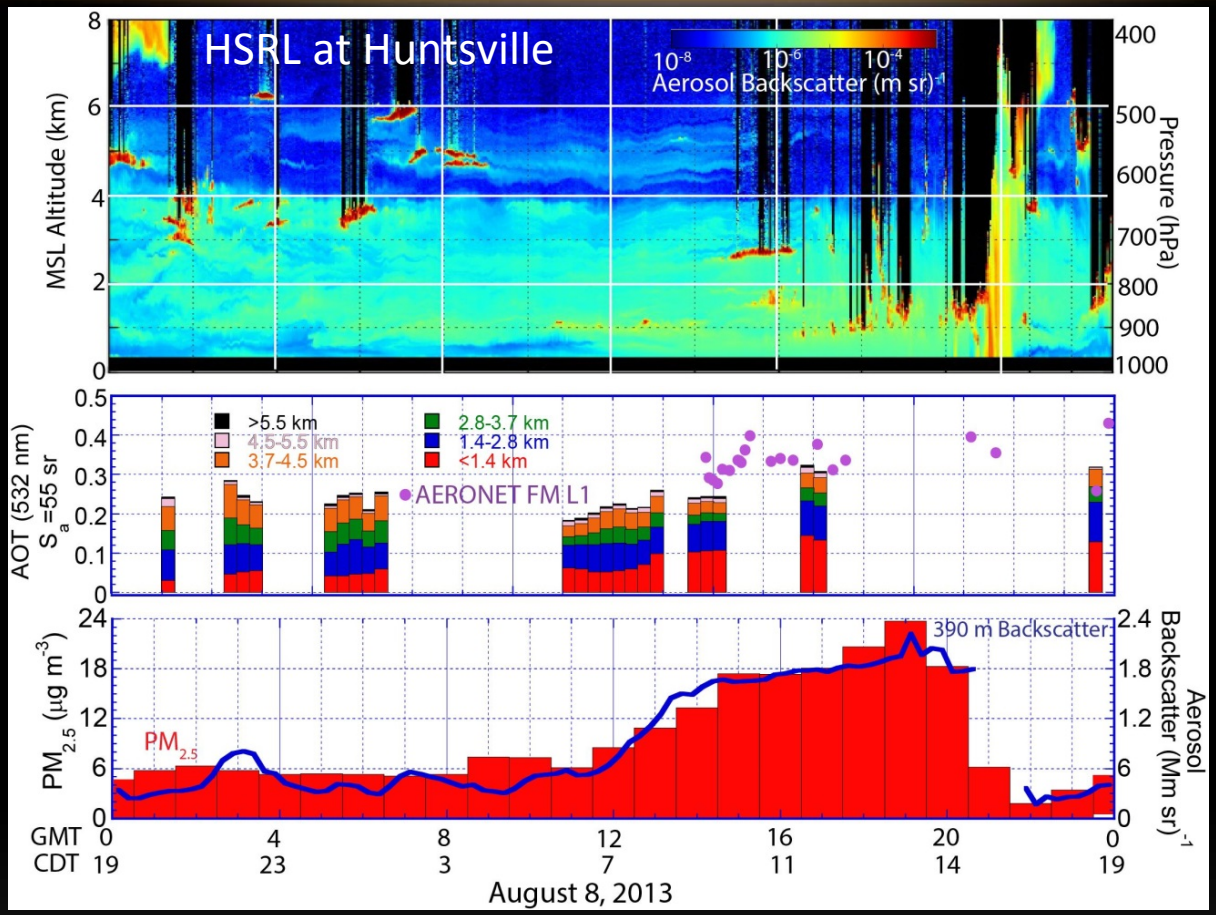






- While all ICAP-MME members did well in predicting AOT, PM2.5 prediction was marginally skillful. PM2.5 is much scattered compared to AOT validation and PM2.5 R2 is only 0.15 for Centreville.
- Models did perform better in the Ohio River Valley (Mammoth Cave), with its high industrial emissions. However in regions with high biogenic emissions the models showed almost no skill (eg. Centerville).
- Interestingly, the ICAP-MME performed best overall.

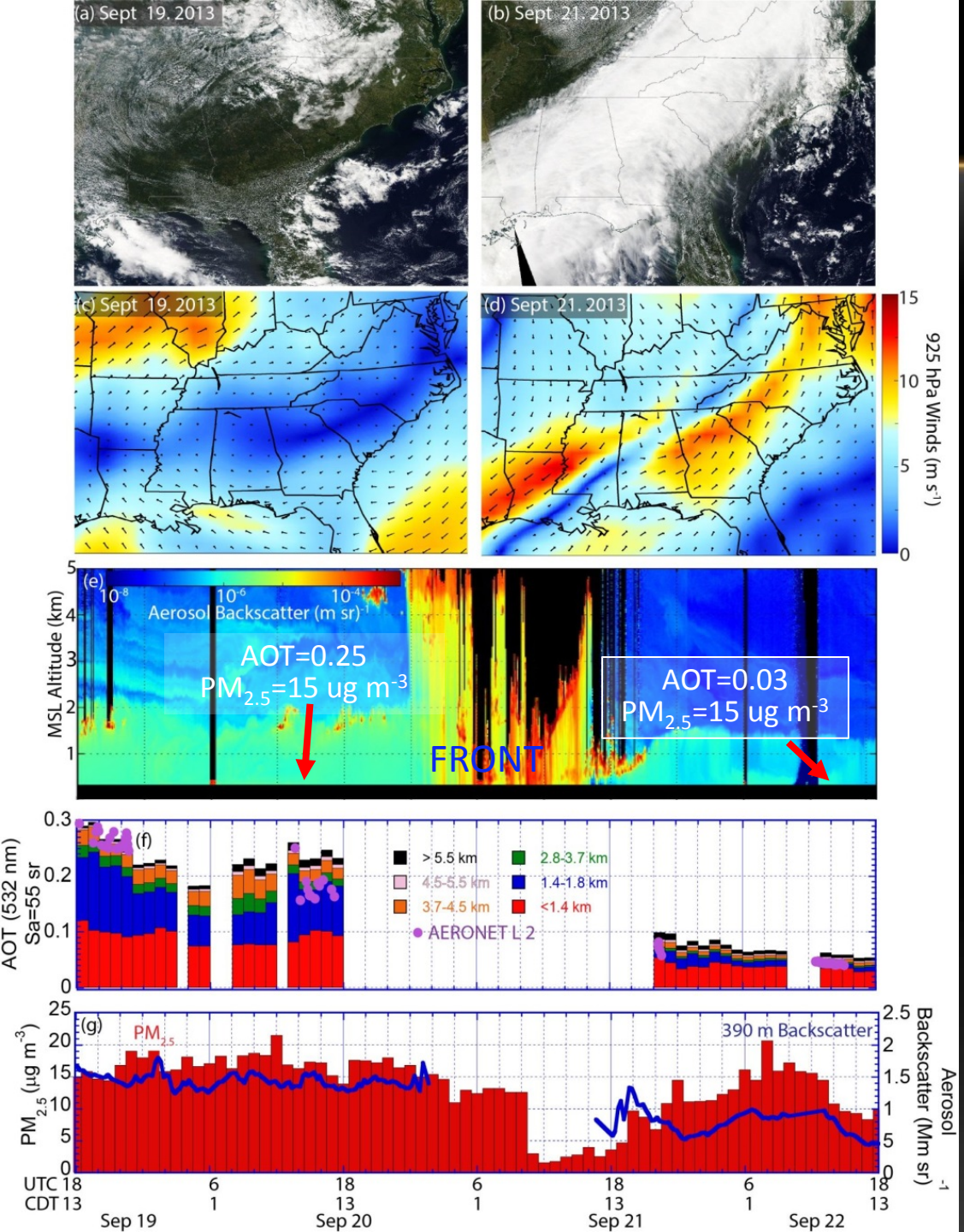
WHAT'S MISSING? IN A CONVECTIVE ENVIRONMENT



Reid et al. (2016)

- The case shows how the near surface environment is decoupled from the column in the convective environment.
- Models are clearly lacking in secondary aerosol production-most likely due to biogenics. This suggests that global models can only be expected to capture synoptic scale variability-and there is a lot going on near the surface.

WHAT'S MISSING? IN A FRONTAL ENVIRONMENT



This case (Reid et al., 2016) shows aerosol dynamics from the SSEC HSRL deployment at Huntsville in a frontal environment.

- It shows the near surface environment is decoupled from the column.
- Notably, surface $PM_{2.5}$ recovers much more quickly than AOT after precipitation events.
- Global models simply can't handle this scale of physics and chemistry.

PROPOSED NEXT UPDATE FOR THE ICAP MME

- Add global speciated (or fine/coarse) surface concentration fields.
- Add vertical component. Start with the MPLNET/EARLINET sites.
- Add meteorological variables that impact aerosol processes:
  - 1) boundary layer related parameters, e.g., surface wind, PBL height, t, q.
  - 2) precipitation, which is key for scavenging
  - 3) RH, which is important for relating aerosol mass to extinction and AOT.
- All these involve data requests for all centers.