2016 NRL Aerosol Overview

Jeffrey S. Reid, On behalf of 7540

US Naval Research Laboratory, Marine Meteorology Division,
Monterey CA **http://www.nrlmry.navy.mil/aerosol/**

8th ICAP Meeting
Washington DC

Updates

- Latest news
- Some fun results
  - Anthropogenic / biogenic fine
  - EnKF development
  - Dust
  - Lidar
  - $PM_{2.5}$ observability in SEUS
  - IR data
  - NWP impacts of a smoke events
  - 2018-CAMP^{2}Ex/PISTON
- The Navy MURI

ICAP relevant aerosol prediction Folks you know are reshuffling

- James Hansen, or former branch head is now Marine Meteorology Division Superintendent. His background is predictability.
- Teddy Holt, the former head of the Decision Support Section & a mesoscale modeler, is now branch head.
- In the aerosol section, Doug Westphal has moved to associate superintendent, replaced by Anthony Bucholtz as section head.
- Peng Lynch has joined civil service, and Juli Rubin will hopefully do so shortly to the Remote Sensing Division.

The Navy Aerosol NWP Group

Anthony Bucholtz	Radiative measurements & tactical decision aids
James R. Campbell	Surface and space lidar studies, cirrus radiation
Cynthia A. Curtis	Products, distribution & transitions
Edward J. Hyer	Satellite data quality & biomass burning
Steve Lowder (SAIC)	Algorithm development
Peng Lynch	Reanalysis, multi model ensemble
Mayra Oyola (NRC)	Dust radiation
David Peterson	Meteorology, biomass burning, remote sensing
Elizabeth A. Reid	Deployments & analysis
Jeffrey S. Reid	Microphysics, radiation, and observability
Juli Rubin (NRC)	Data assimilation & ensemble modeling
Walter Sessions (UW)	Analysis
Annette L. Walker	Dust sources & operational outreach
Douglas L. Westphal	Emeritus!

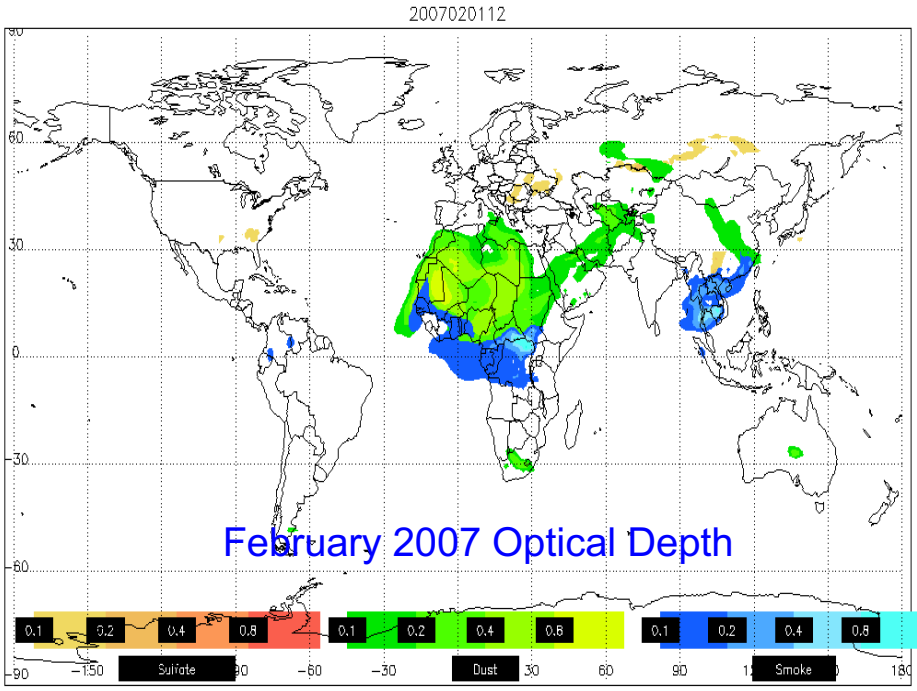
Plus Jianglong Zhang's branch office at UND, Robert Holz w/ SSEC, and now Steve Miller (CSU) and Co in the MURI

Navy Aerosol Modeling Spanning Global to Mesoscale

http://www.nrlmry.navy.mil/aerosol/

Global Modeling: Navy Aerosol Analysis and Predication System (NAAPS)

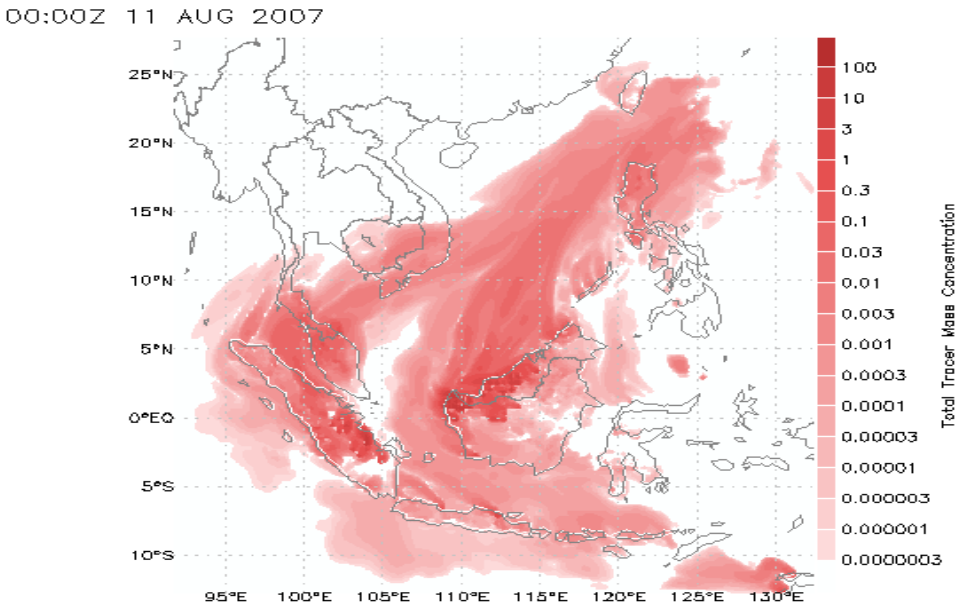
- Navy's operational global aerosol model; now at 1/3 degree resolution using NAVGEM meteorology.
- 6-day forecasts of dust, smoke, pollution, and sea salt run 4x/day
- Assimilates quasi-operational MODIS aerosol & uses geostationary fire data streams.



February 2007 Optical Depth

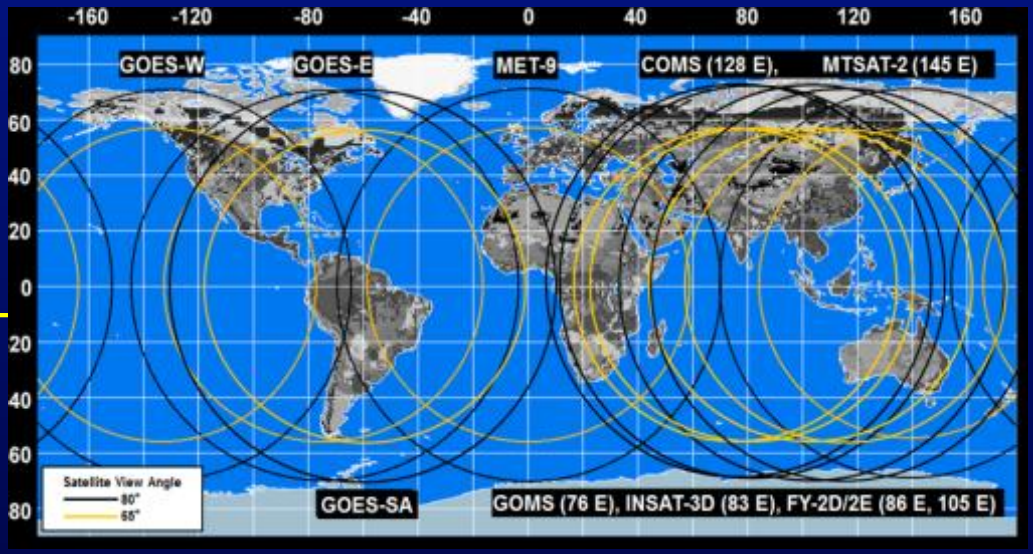
Mesoscale Modeling: Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS®)

- COAMPS® is a mesoscale atmospheric model fully coupled with the ocean.
- Dust forecasts are operational at FNMOC and now a "NAAPS" like aerosol suite has been implemented.



Operational Satellite Data Inputs to NAAPS

- Aerosol Optical Depth
  - Terra and Aqua MODIS used operationally
  - AVHRR and VIIRS over water can be turned on if needed
  - MISR in the reanalysis
  - Looking hard at Himawari-8
- Aerosol vertical profiles
  - Experimental 2D/3DVAR system to assimilate CALIOP backscatter data (Zhang et al. GRL 2011) for KORUS AQ.
  - Initiating single observation experiments with Wisconsin HSRL deployment in Huntsville and Seoul.
- Satellite fire observations
  - Reanalysis uses MODIS only FLAMBE, whereas operationally fused MODIS/Geostationary
  - Terra and Aqua MODIS, GOES-EAST, and GOES-WEST used operationally
  - Currently evaluating global geostationary observations
    - METEOSAT, MTSAT, COMS



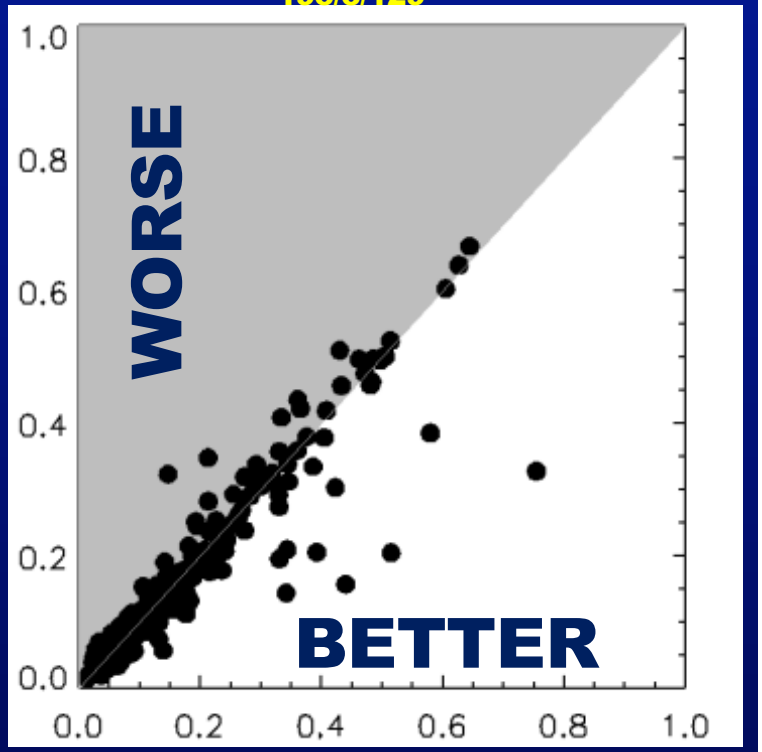
Upgrades to operational NAAPS based on reanalysis + KORUS

POC: Edward Hyer-edward.hyer@nrlmry.navy.mil

- Upgrades from reanalysis run
  - (Lynch et al. GMD 2016)
  - Primary/secondary aerosol tracer
  - Tuned smoke sources
  - Modified sink terms
  - Updated background lidar climatology
- Upgrades from KORUS experiment
  - Upgrade reanalysis run to 1/3 degree resolution
  - 3-hourly data assimilation
- Upgrade to MODIS Collection 6
  - AOT data assimilation
  - FLAMBE fires
- Comparison of KORUS-NAAPS to AERONET shows big improvement (vs. operational NAAPS):
  - Sharp reduction in global bias (especially E. Asia)
  - Reduction of RMSE globally and in many regions
  - Improved slope, esp. in E. Asia

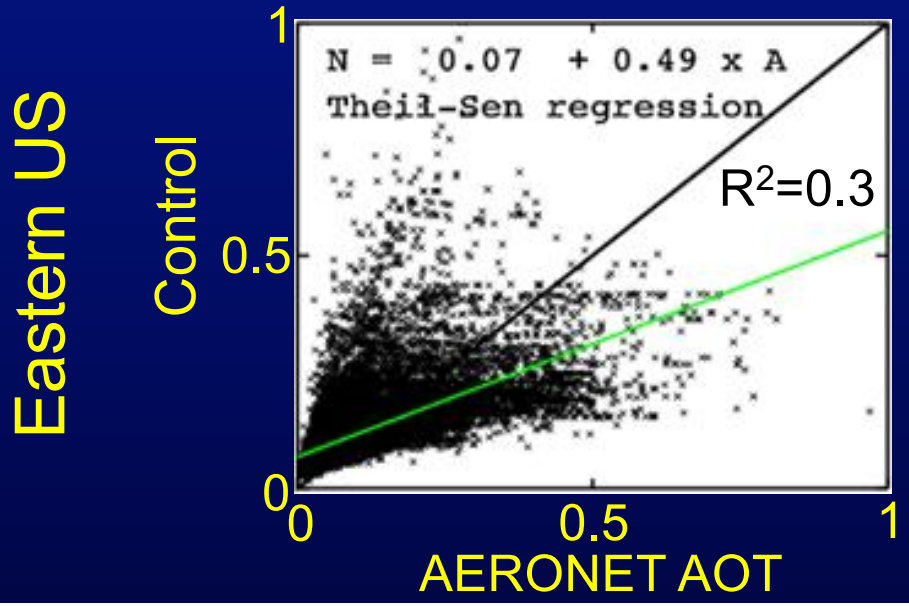
- **NAAPS v1.4; FLAMBE v1.6; will be operational at Navy FNMOC October 2016**

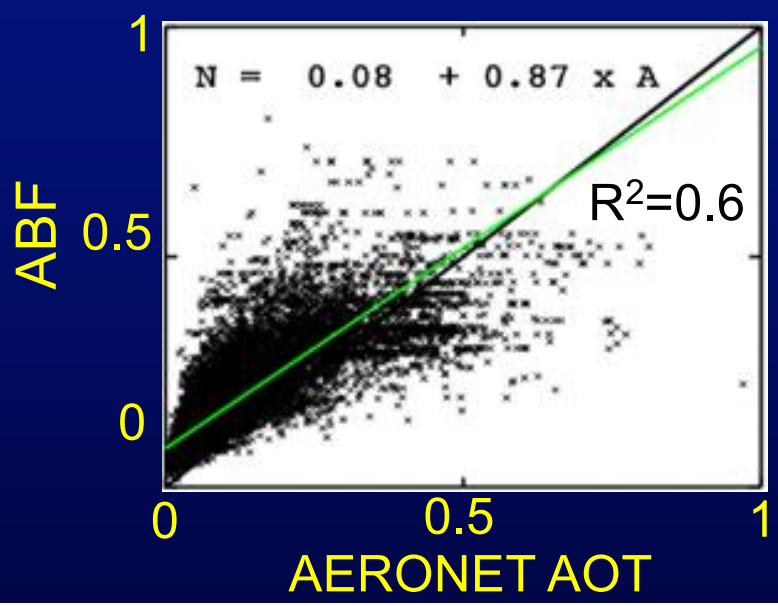
AOT vs. AERONET
RMSE by site
May 2016 (KORUS)
327 sites (N>=100)
Better/NoChange/Worse
195/3/129



Updates to operation this fall
Combined Anthropogenic/Biogenic Fine
POC: Peng Lynch

- Given that anthropogenic and biogenic emissions form a photochemical "soup," several years ago NRL embraced the beast that it is, and replaced sulfate with "Anthropogenic & Biogenic Fine."
- ABF was implemented by Peng Lynch as single bin approximated conceived by Dean Hegg based on Bond et al. POM+BC, and a conversion rate from MACCity and MEGAN based source of aromatics, terpenes, and isoprene.
- This has been in the reanalysis and parallel runs for a couple of years and is now working its way to operations.



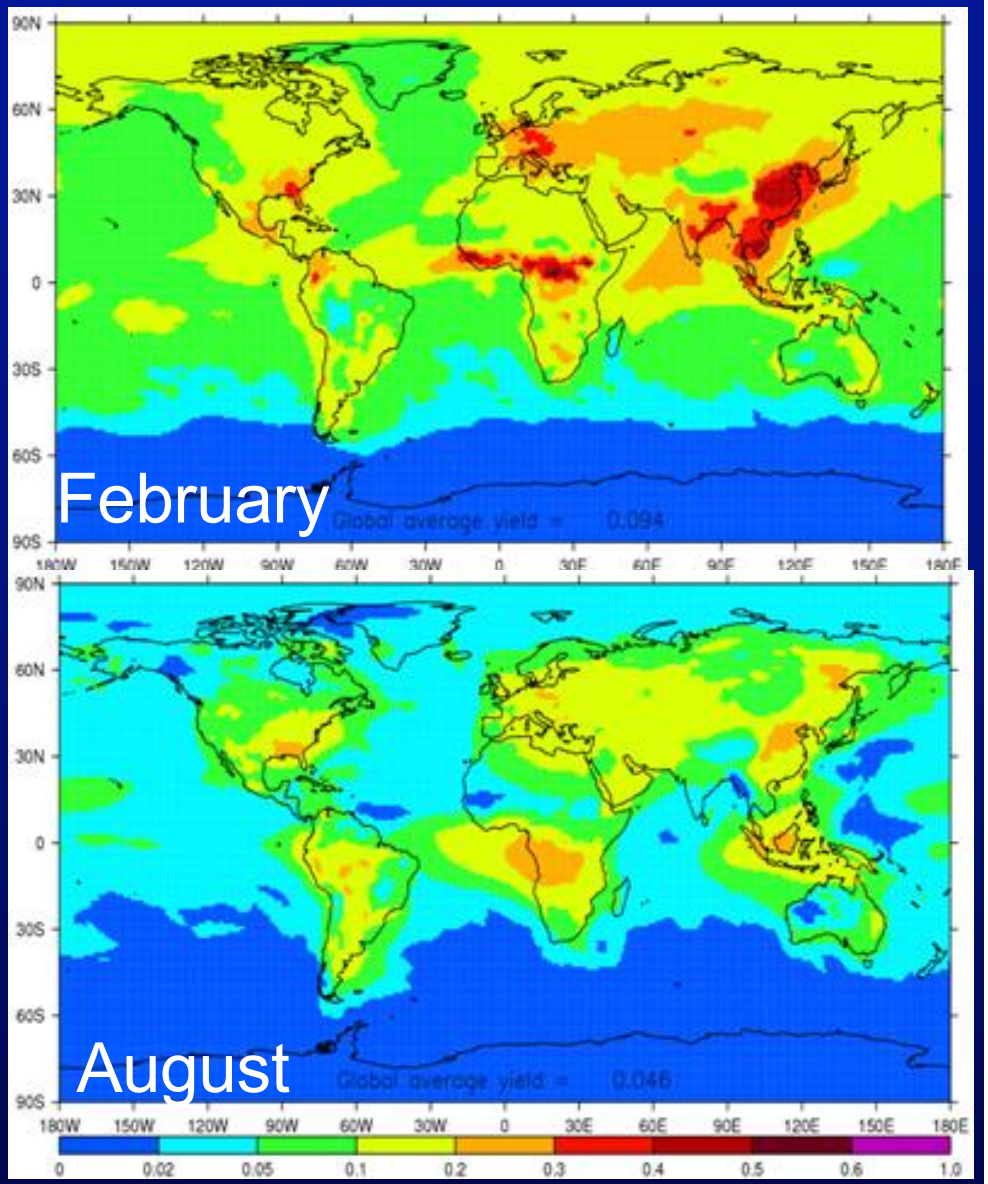


Regional SOA Yields

NAAPS currently cant transport VOCS, so we do a static input.

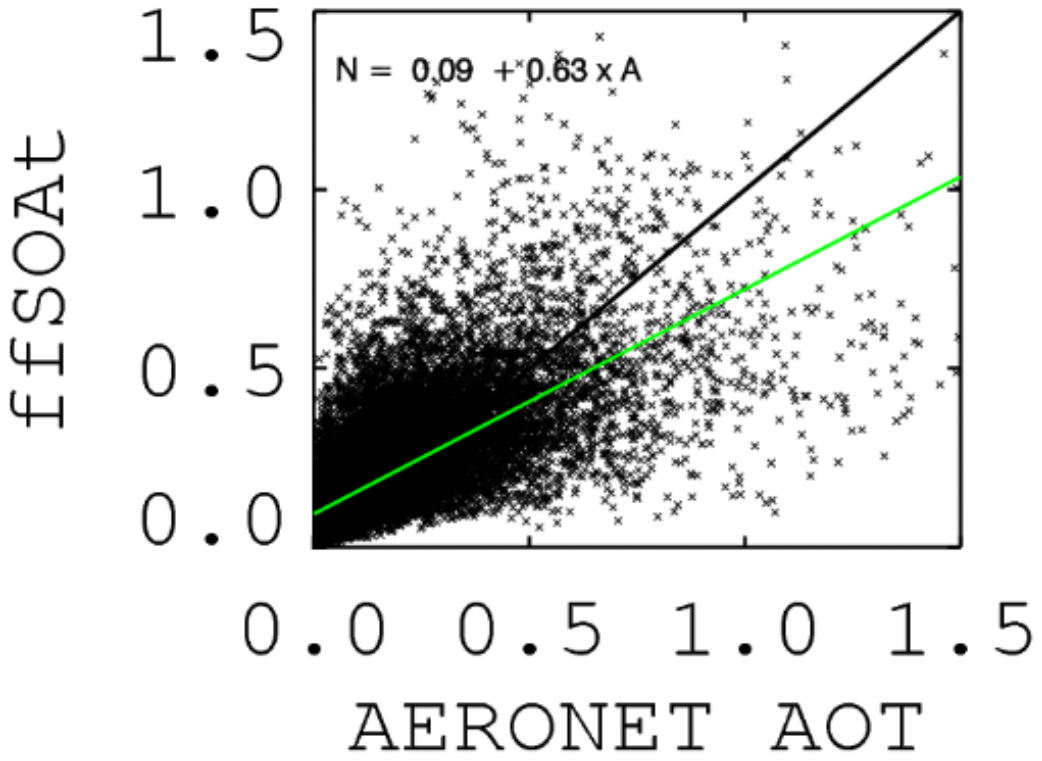
The upside: Significant improvements in areas with urban influence-particularly Asia.

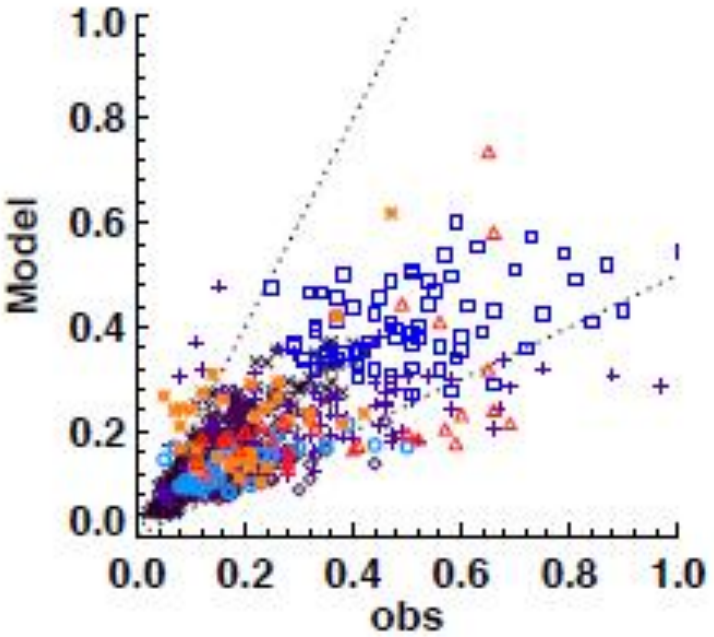
Downside: We tend to over produce in some remote regions, leading to a high bias for low AOTs



OK, how about something more complex?

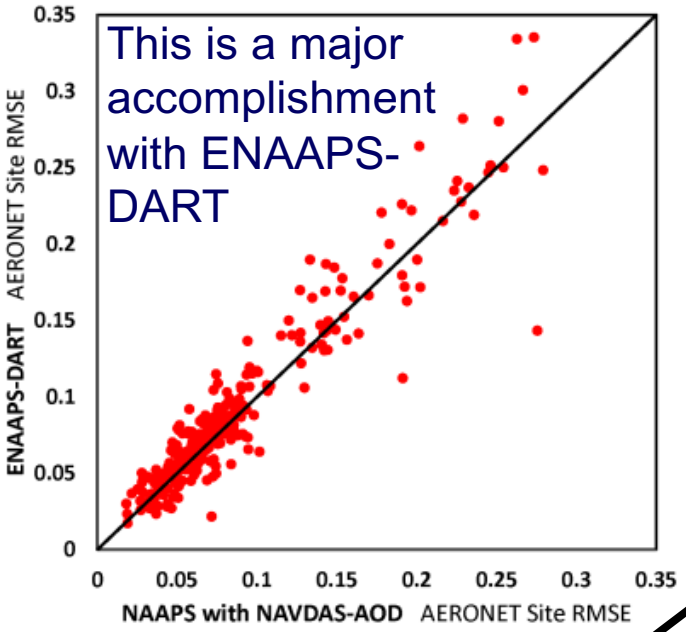
- NAAPS: R2=0.52, bias = 0.051, slope=0.63
- PNNL-MMF: R2=0.55, bias= -0.13, slope ~ 0.66





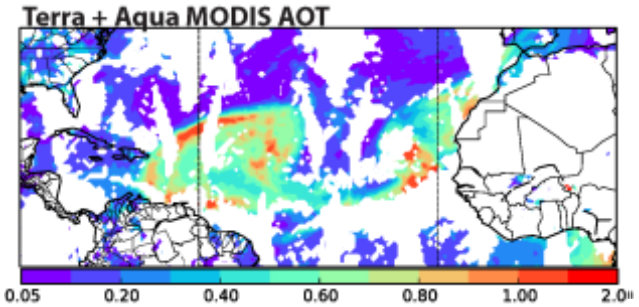
Next. ENAAPS-DART MODIS Prototype Going Quasi Operational at DSRC this fall.

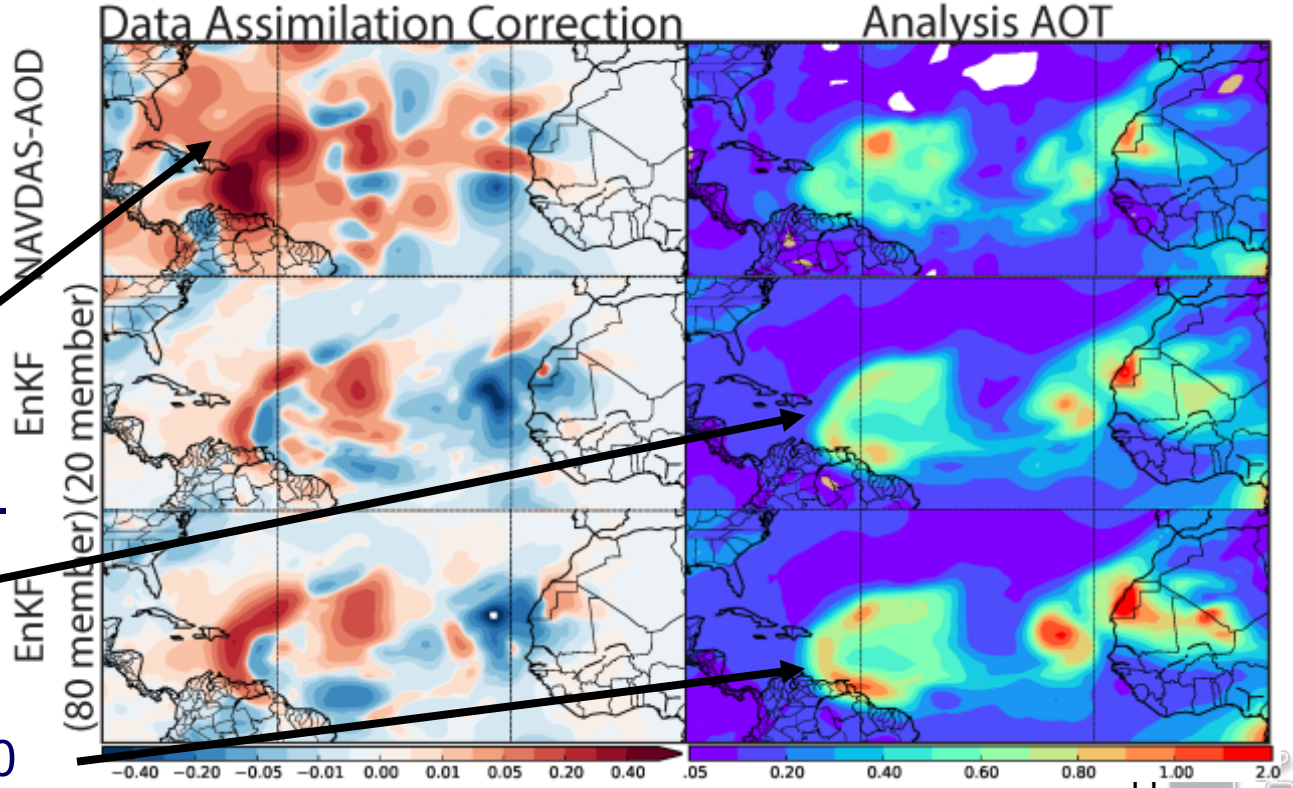
POC Juli Rubin-juli.rubin.ctr@nrlmry.navy.mil



2. Case studies reveal differences

Dust Event (Aug 2, 2013)





NAVDAS-AOD: observationally driven, produces large DA corrections.

EnKF: captures dust front shape (not magnitude).

Significant improvement with 80 members in magnitude and position.

NRL-MRY Saharan Air Layer website

www.nrlmry.navy.mil/SAL.html

POC Arunas Kuciauskas: Arunas.Kuciauskas@nrlmry.navy.mil

Standard Satellite Imagery:

- Visible
- IR
- True Color
- Nocturnal Low Clouds
- Dust
- TPW
- Aerosol Optical Depth

Coming soon: Lidar Instruments:

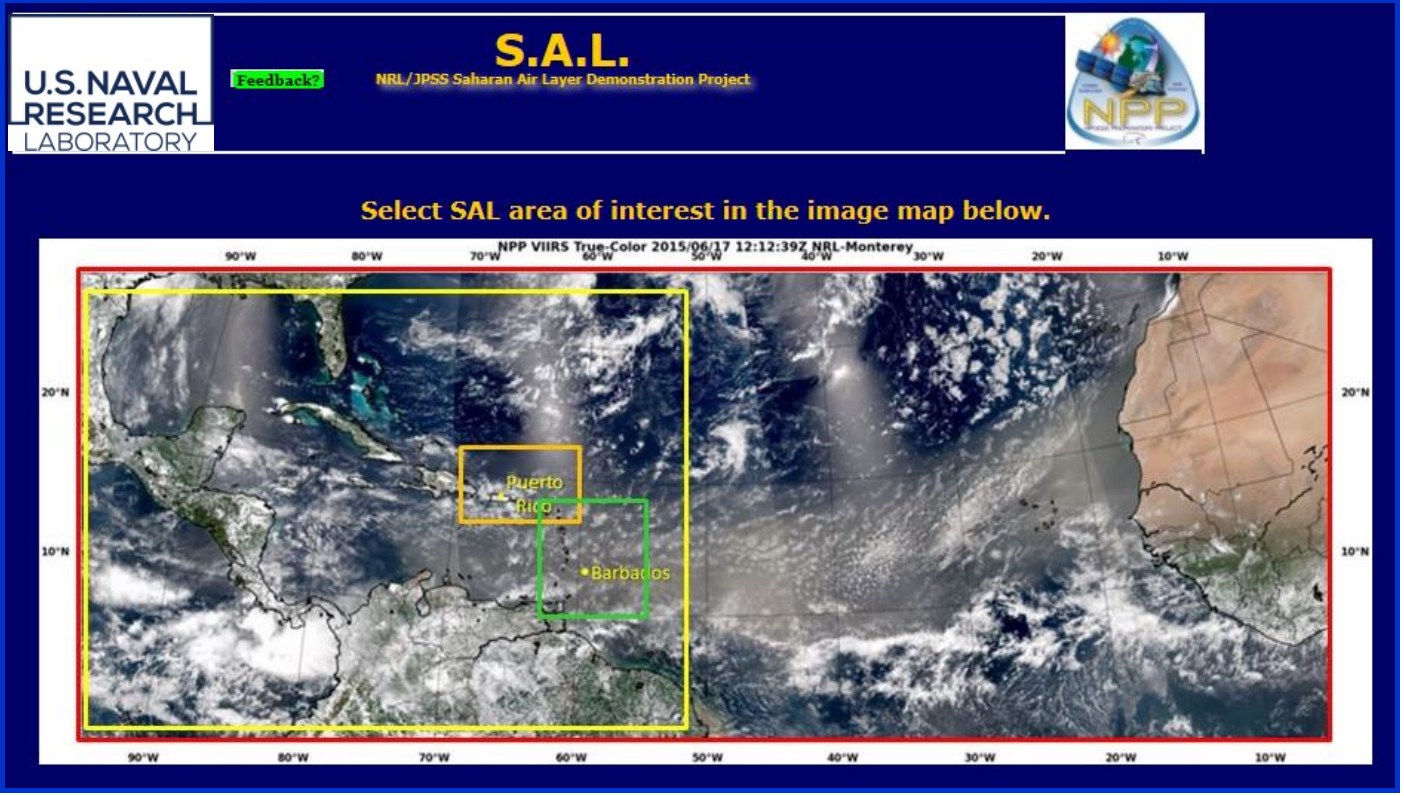
- CALIPSO/CALIOP

Ground-based instruments:

- MPLNET (Lidar)
- TEOMs (PM2.5 & PM 10 measurements)

Modeling:

- NAAPS dust model using VIIRS and MODIS AOD
- NAVGEM overlays



Next step: Moving verification to the infrared

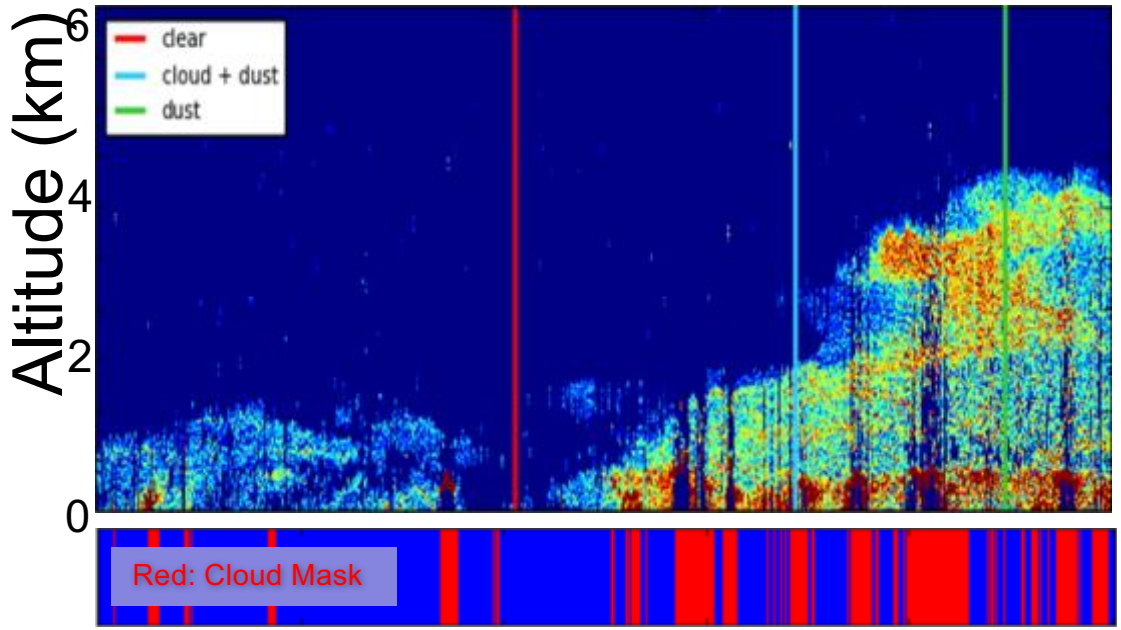
Challenge: While bias correction in the IR is fairly straightforward, the community lacks end to end verification of infrared radiances from observation, meteorology modeling and dust radiative impacts.

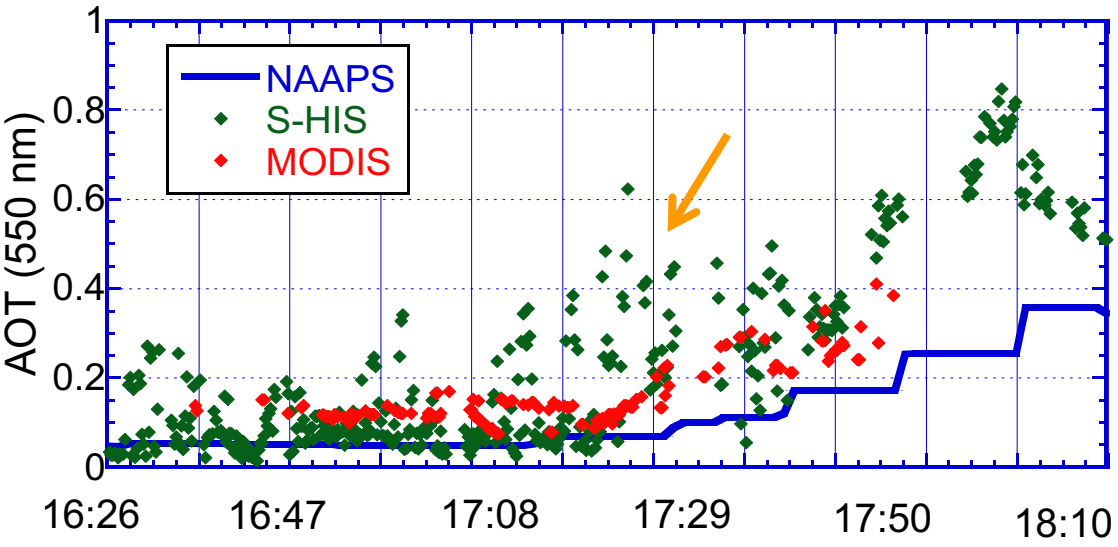
Based on the HS3 dataset, an optimal estimation dust retrieval was developed by Wisconsin using Scanning Hyperspectral interferometer (S-HIS) data.

- Visible and IR AOT
- Effective radius
- Mineralogical family

Low cloud screening is the current challenge. Current noise floor for AOT is 0.4. Not bad for IR only…

Expect a CrIS algorithm delivery to the Community Satellite Processing Project (CSPP).





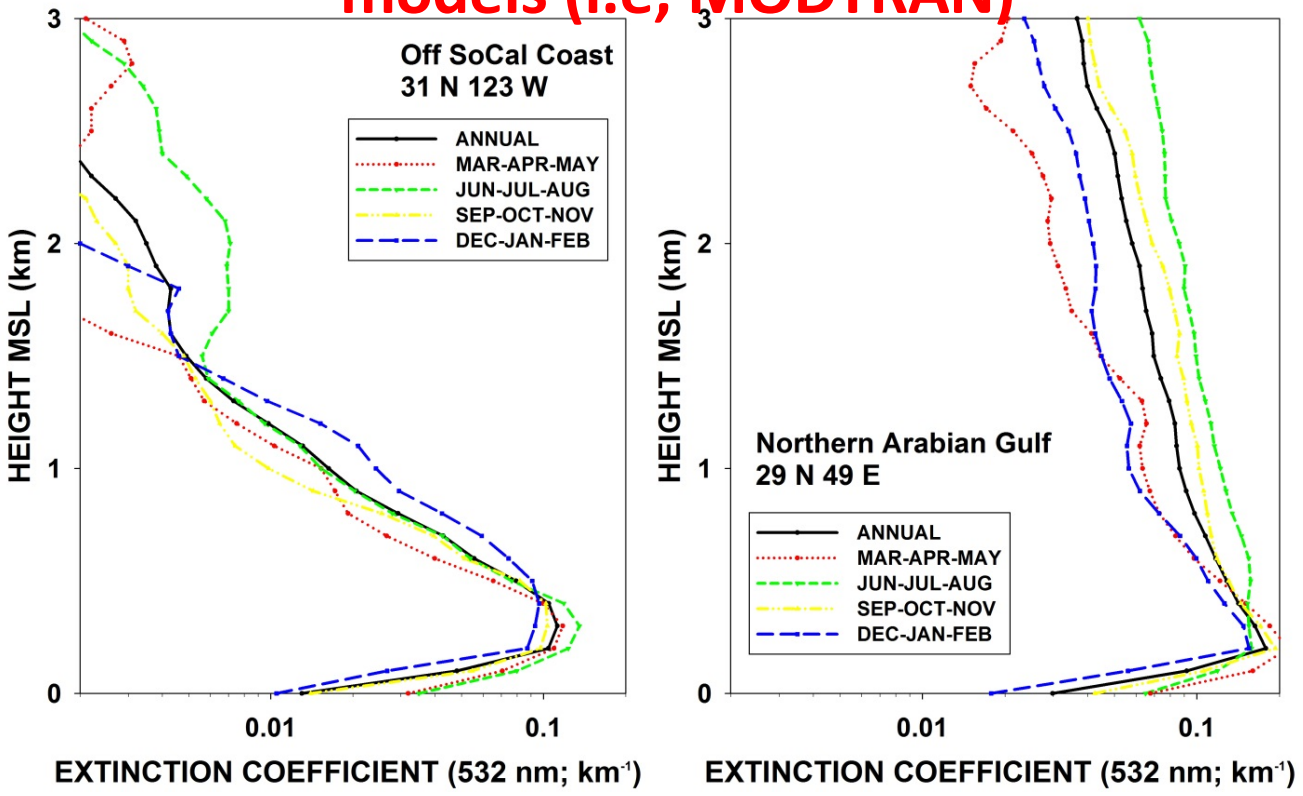
Global 3-D Aerosol Climatology

POC: James Campbell: James.Campbell@nrlmry.bavy.mil

- CALIPSO V3 QC Level 2 Aerosol Profile Data '06-'15
- 2°x2° or 5°x5° Global Resolution (80S to 80N)
- Aerosol Extinction Coef. @ 0.532 µm
- Data Aggregated as Function of:
  - Season
    1. Monthly
    2. Seasonal
    3. Bi-Annual
    4. Annual
  - Time of Day
    1. Day
    2. Night
    3. Total
  - Spatial (2x2)
    1. Land
    2. Coast
    3. Water
    4. Total
  - Speciated
    1. Marine
    2. Dust
    3. Polluted Continental
    4. Clean Continental
    5. Polluted Dust
    6. Smoke

FY17 – Extrapolate to additional wavelengths from .355 to 2.0 µm using speciated extinction/OPAC models

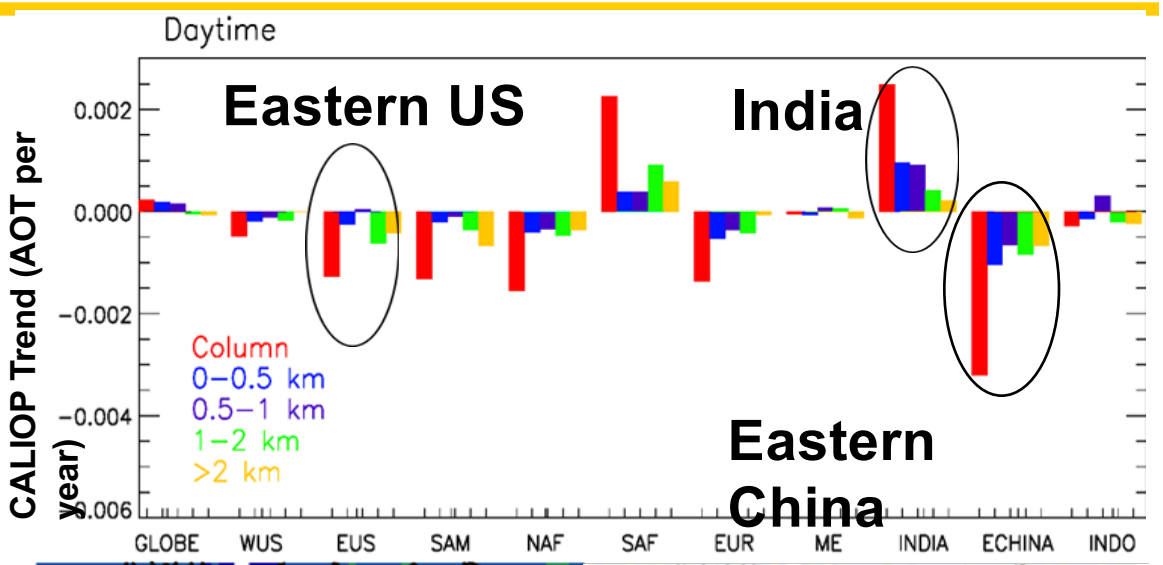
Aerosol turbidity is far greater than captured by simple transmission models (i.e, MODTRAN)

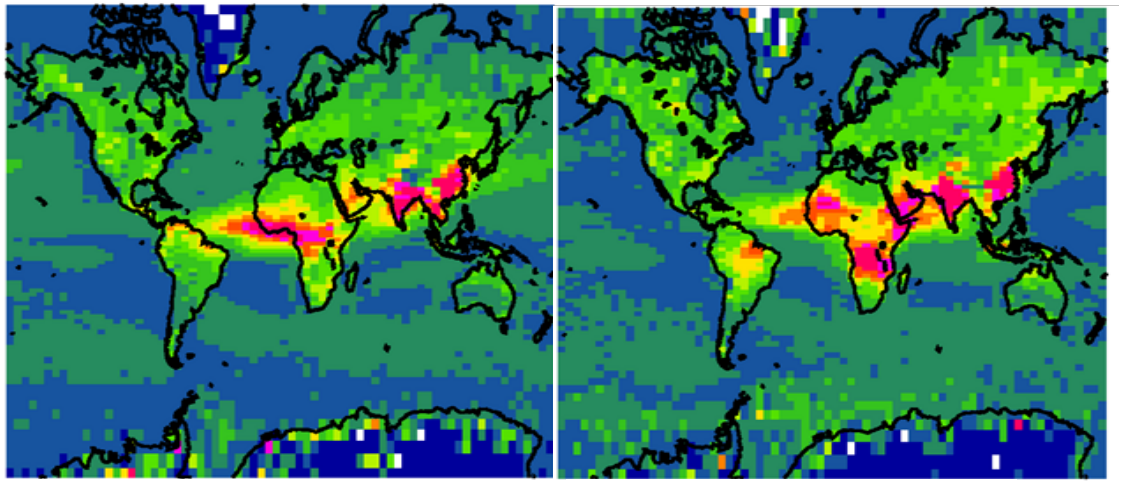


Temporal Variability of Aerosol Optical Thickness Vertical Distribution Observed from CALIOP

POC: Travis Toth & Jianglong Zhang , UND

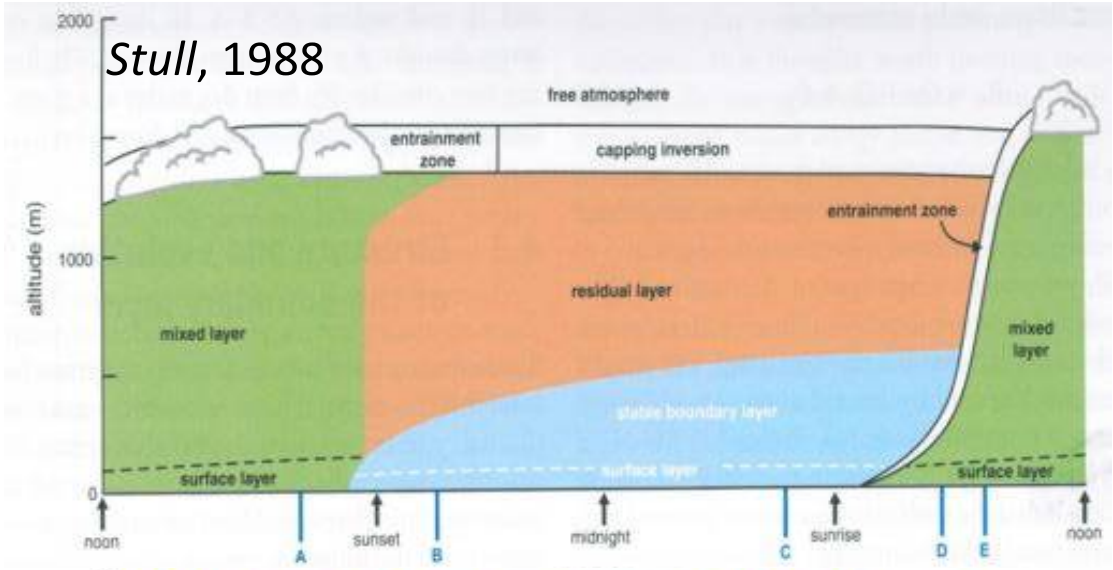
- Using more than 8 years of CALIOP data, temporal variations of aerosol particles are evaluated in the vertical domain for the first time
- Column-integrated AOT-wise, the longer-term variations detected from CALIOP are comparable to passive-based analyses for most regions
- Contribution of this study is to understand the source of the column-integrated AOT trends vertically
- For example, an increasing trend in AOT is found over India, primarily due to increasing surface aerosol concentration
- On the other hand, the decreasing AOT trend found over the Eastern U.S. is mostly caused by changes in elevated aerosol plumes

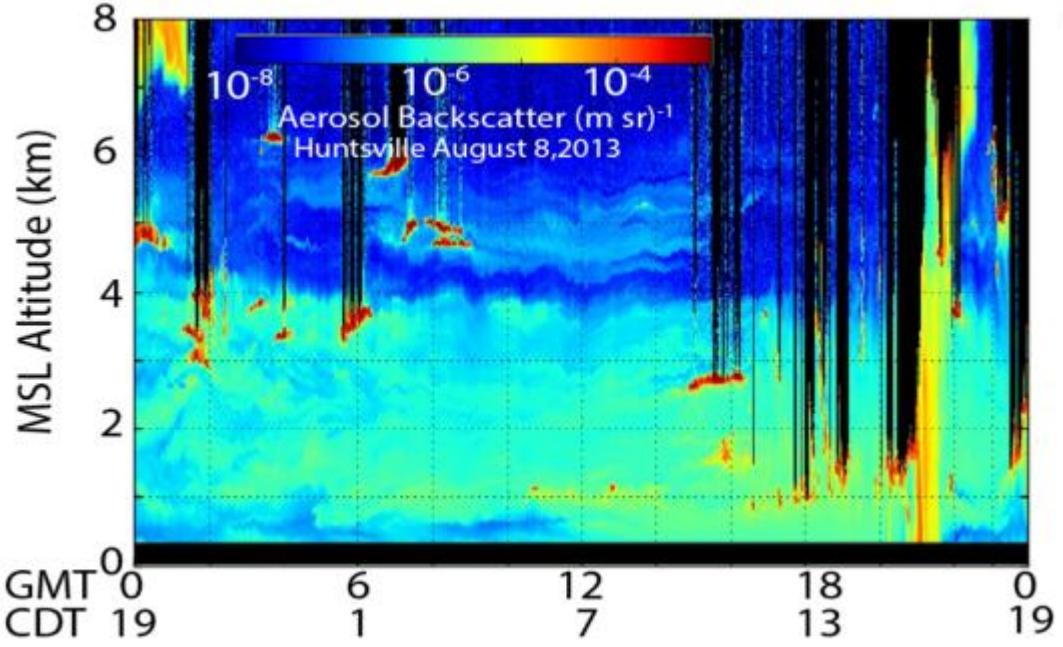




Toth et al., 2016 (JGR-Atmospheres, accepted)

Moving from AOT to 3 dimensions
Conceptual model of PBL lifecycle

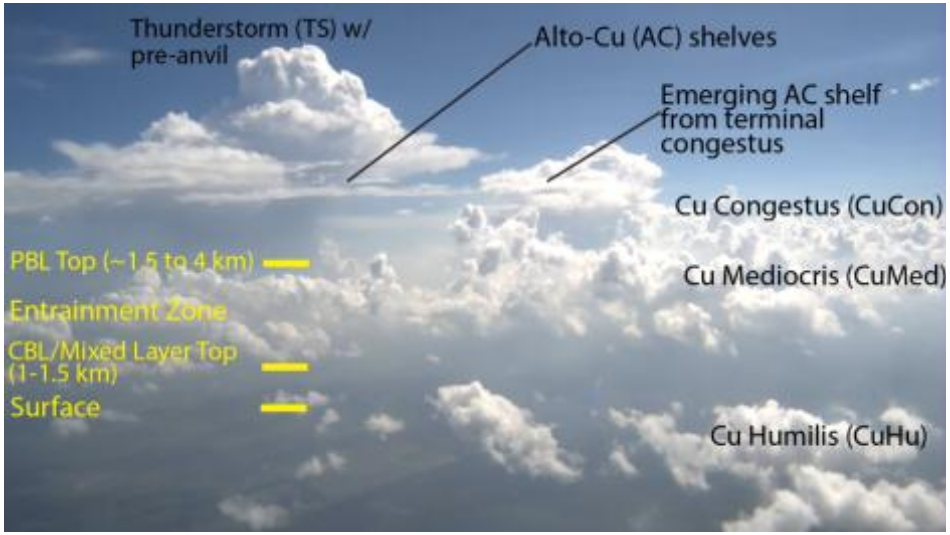




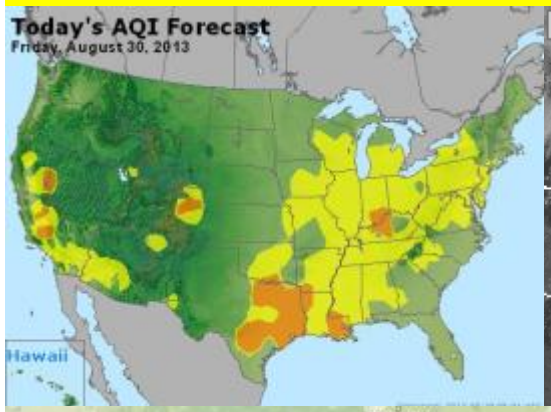
The surface and free troposphere are connected by mixed layer forced by solar radiation. Between the mixed layer and free troposphere is an entrainment zone, often aided by PBL clouds.

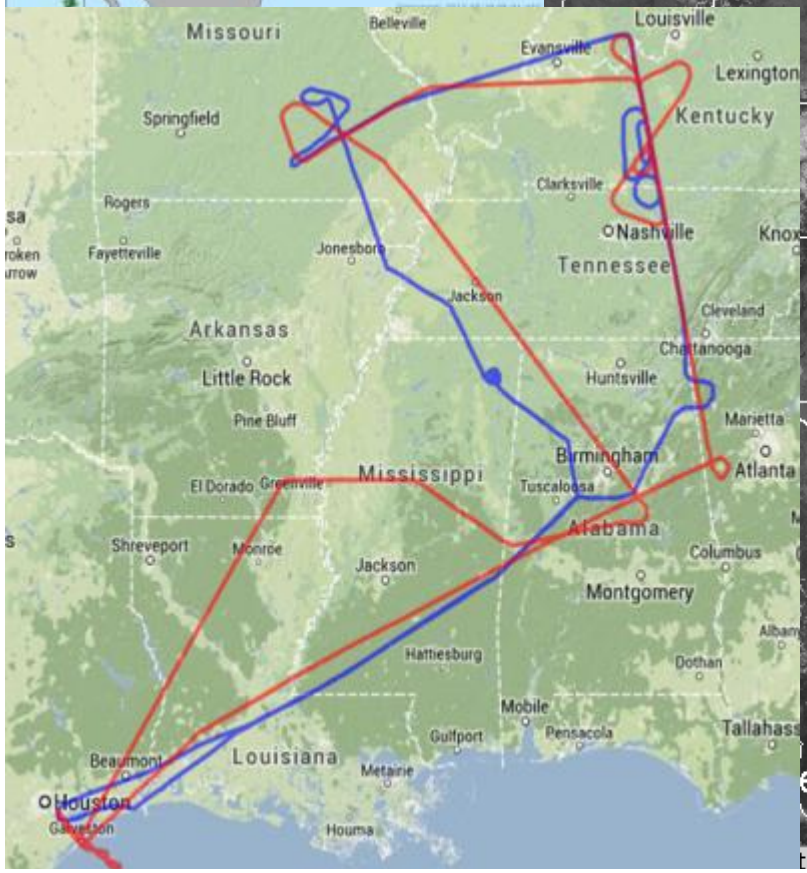
The mixed layer collapses at sundown leaving a residual layer of moisture and other atmospheric constituents.

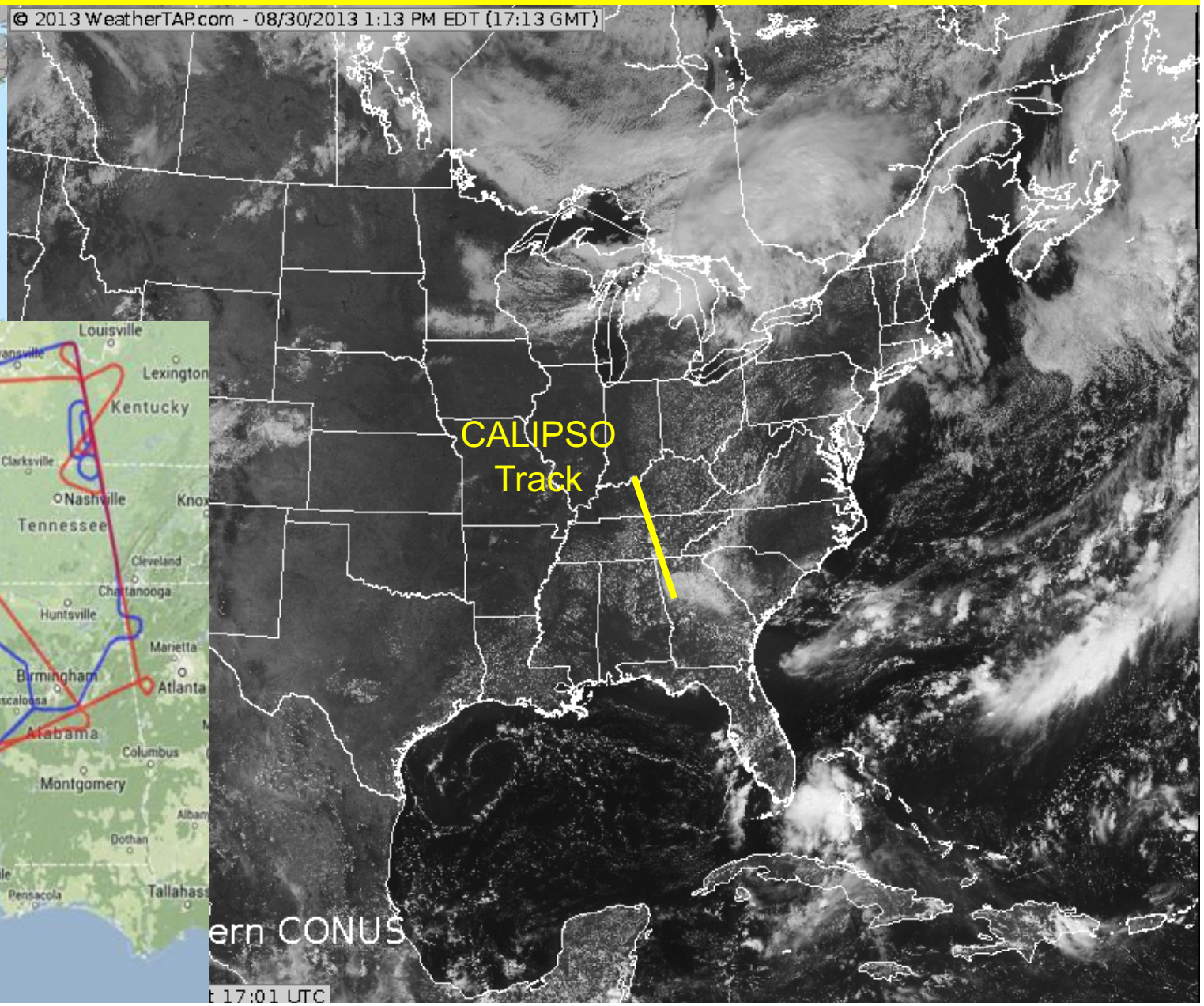
Fueled by latent heat the entrainment zone can be 2-5 km deep. This is messy…

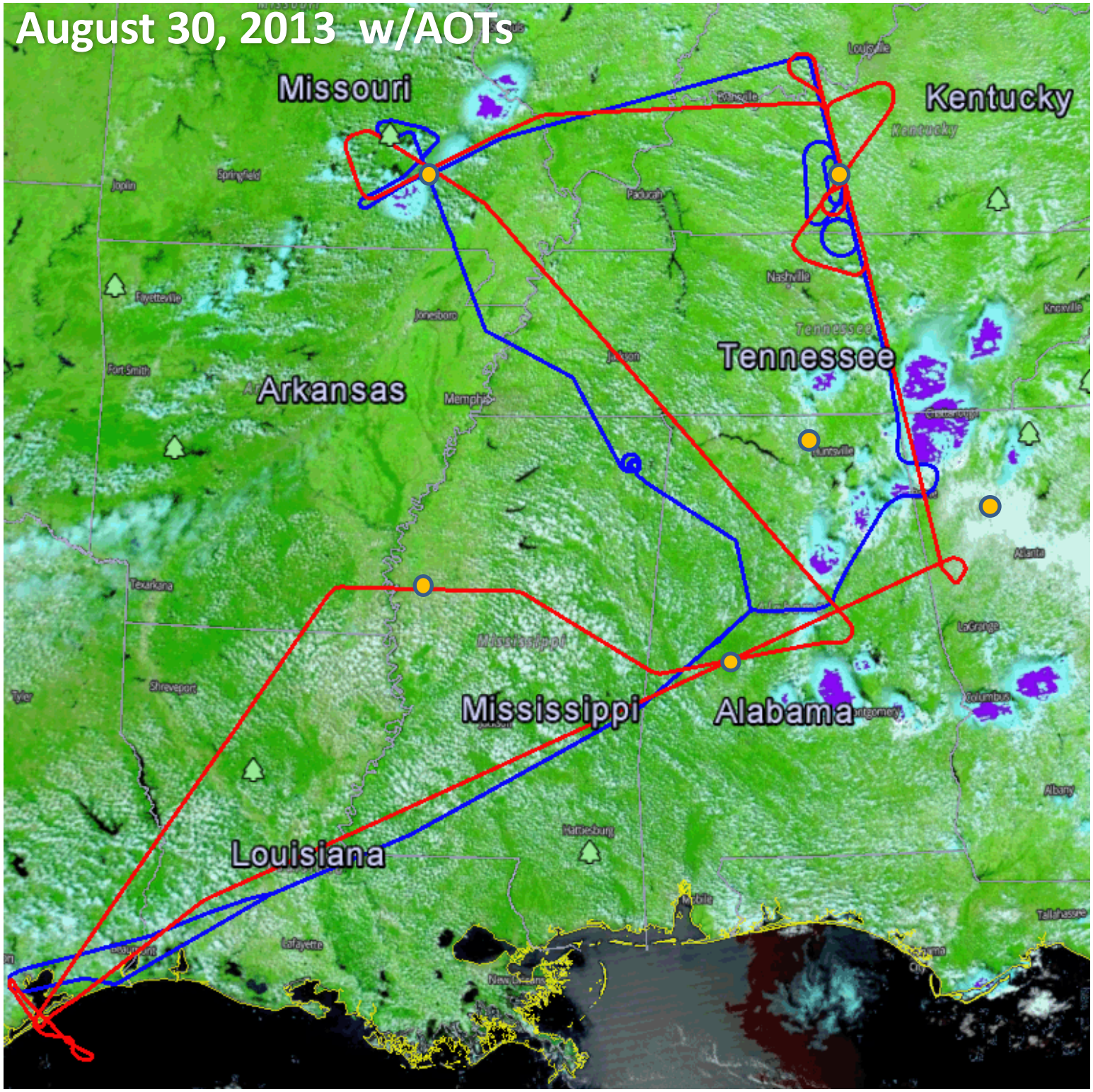


From climatology to instantaneous
Looking at August 30th, 2013









Mammoth Cave (0.24)

Mingo (0.13)

Huntsville (0.47)

Yorkville (0. 5)

Leland (0.5)

Birmingham (4star-)

Centreville x2 (0.4-0.5)

Aug 30 Stats

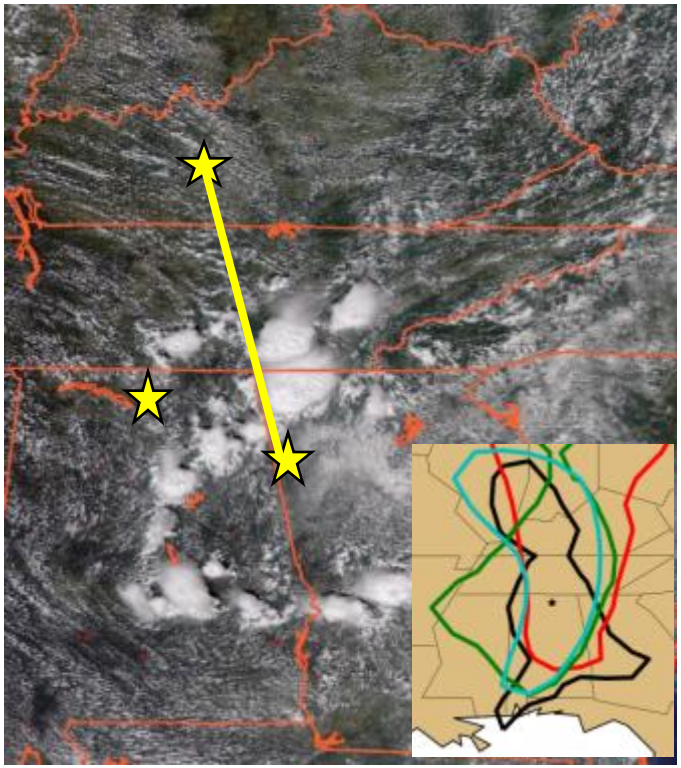
Qualitatively what I expect, what about quantitative?

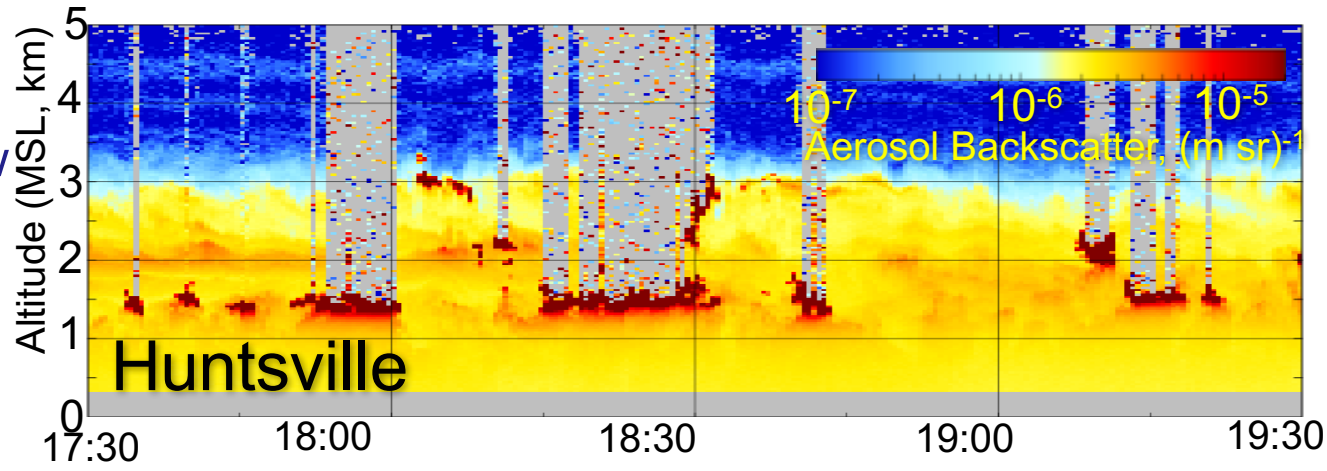
Region	PM1 CU	$SO_4^=$:Org CU	AOT 500nm	Mixed Layer Lidar ratio	$kappa_{GF}$ DASH-SP	F(80) LARGE	F(90) NOAA
S LA	27/16	0.6/0.65	~0.3	~66	0.39 / 0.47	1.5/1.45	2.3/2.36
S Miss	24/19	0.3/0.3	~0.35	n/a	0.26 / 0.32	1.3/1.35	2.0/1.85
S Birm/Cent	19	0.4	~0.4	58	0.33	1.38	2.2
Mammoth Cave	18	1.2	~0.25	44	0.53	1.7	2.5
Ohio RV	12	0.8	0.2-0.3	54	0.40	1.55	2.65
Ozarks	9	0.6	0.13	42	0.34	1.4	2.4
NE Miss	18	0.6	0.2	n/a	0.41	1.45	2.2
Variability	3	4	4	1.6	2	1.3	1.3

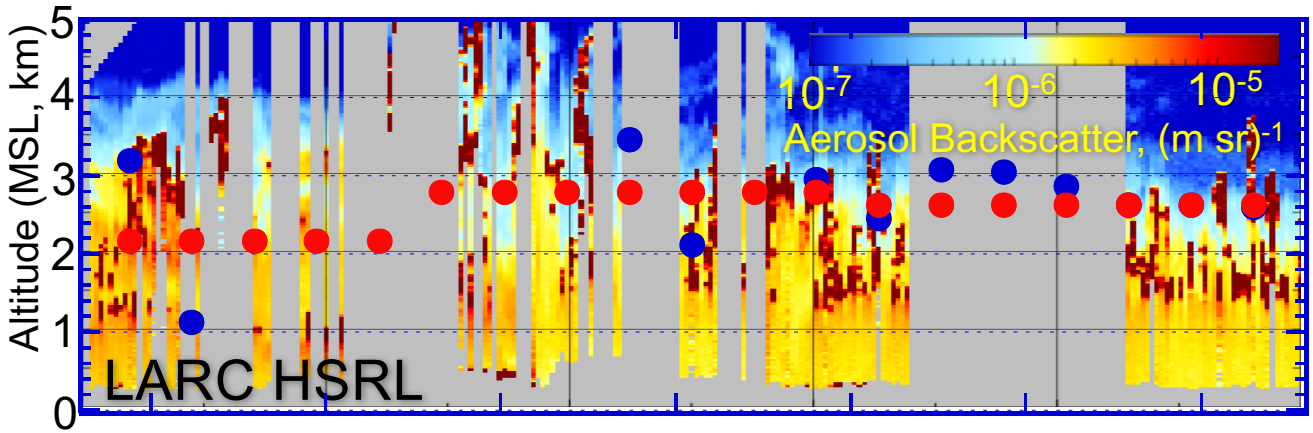
Pulling it all together

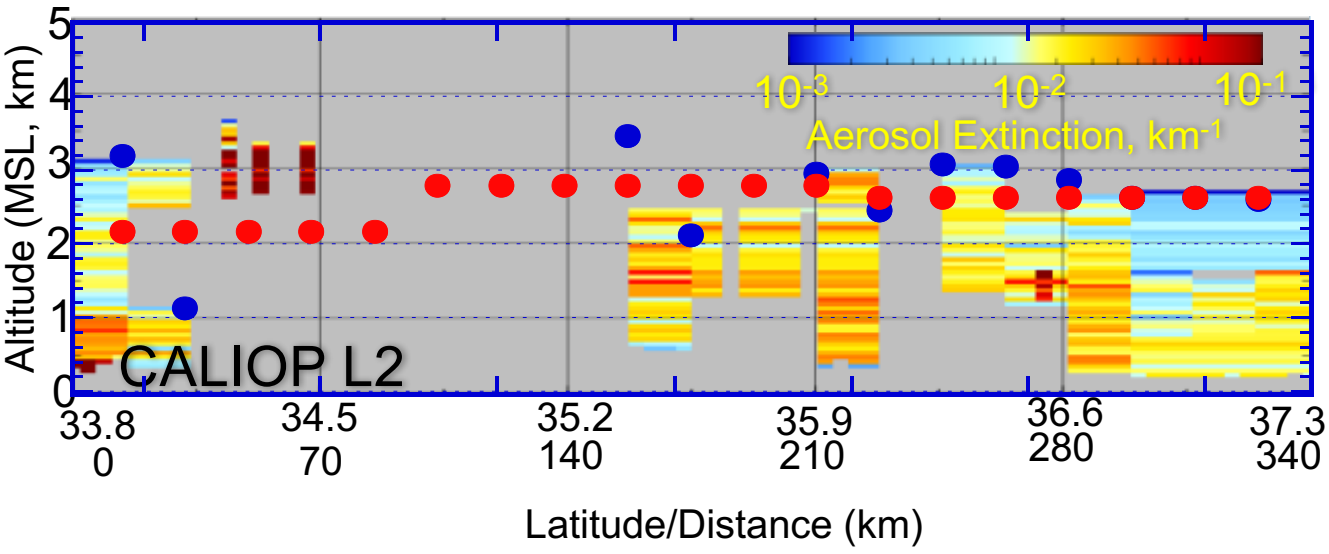
Aug 30, 2013

We need all lidar points of view







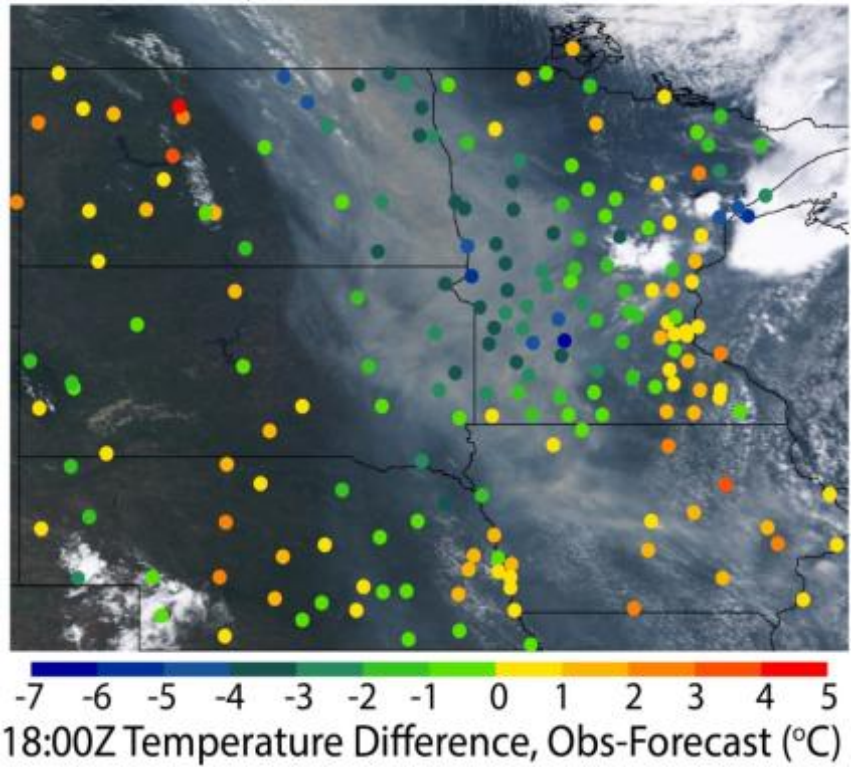


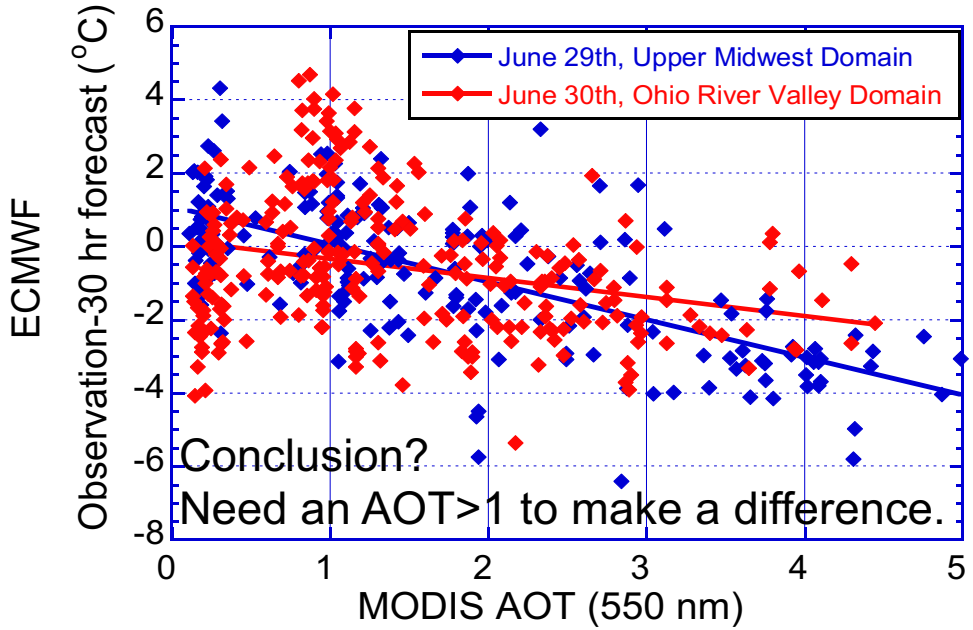
Starting to look hard at aerosol-NWP impacts with the help of Ang & ECMWF (Jianglong Zhang et al., 2016)

Challenge: Need to bound the extent aerosol particles influence NWP.
Lets look for a BIG signal.
Surface temperature is the canary in the coal mine.
Canada smoke June 2015.

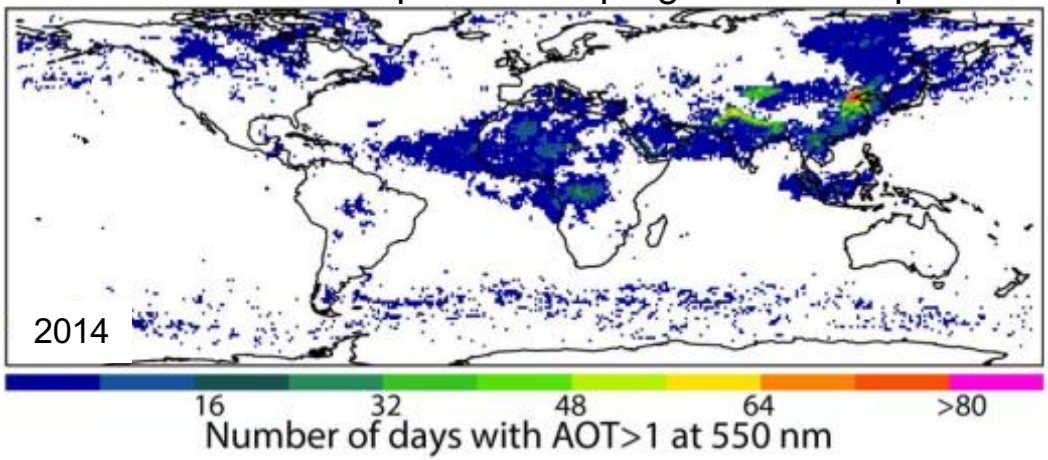
Zhang et al. (Submitted)

June 29th, 2015 Obs-ECMWF 30 hr Forecast





How often a problem? Not very often.
But not so simple. Need prognostic absorption



Summer 2018- Field Work.

NASA Cloud, Aerosol, and Monsoon Processes Philippines Experiment (CAMP^{2}Ex)

ONR Propagation of Intraseasonal Tropical Oscillations(PISTON)

Overview:

- Funding Agency: ONR and NASA
- Proposed Dates: Aug-Sept 2018
- Locations: Subic Bay Philippines, South China, Sulu, Celebes Seas &, WestPac
- Platforms: NASA P3, RV Thompson

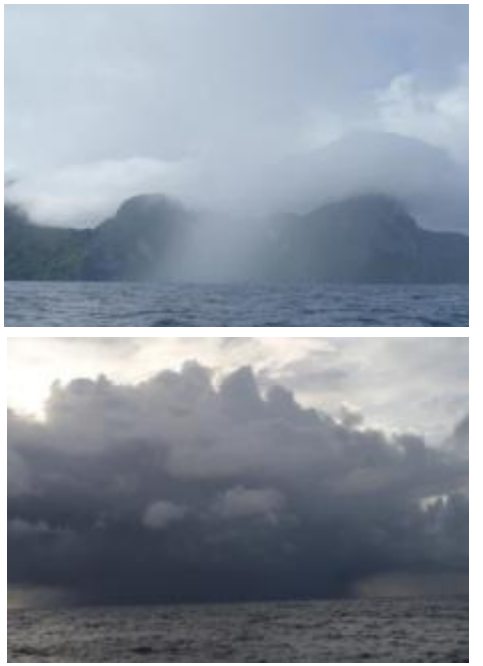
P3

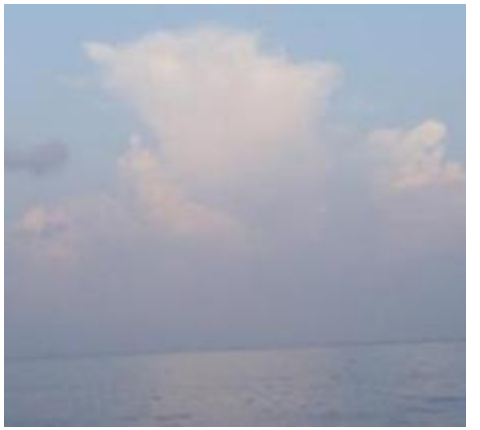
CAMP^{2}Ex Science:

- Determine the extent to which aerosol particles are responsible for modulating warm and mixed phase precipitation in tropical environments
- Investigate if aerosol induced changes in clouds and precipitation feedback into aerosol lifecycle
- Philippines partnership: a) Land surface change impacts on precipitation fields; b) Regional precipitation monitoring

PISTON Science:

- Motivated by the predictability barrier observed in numerical simulations of the Madden-Julian oscillation and other intra-seasonal tropical oscillations as they propagate across the Maritime Continent.
- The geographic focus of effort is the Philippine Archipelago at meso-synoptic scales including propagating of MJO and BSISO


Pristine Conditions


Polluted Conditions

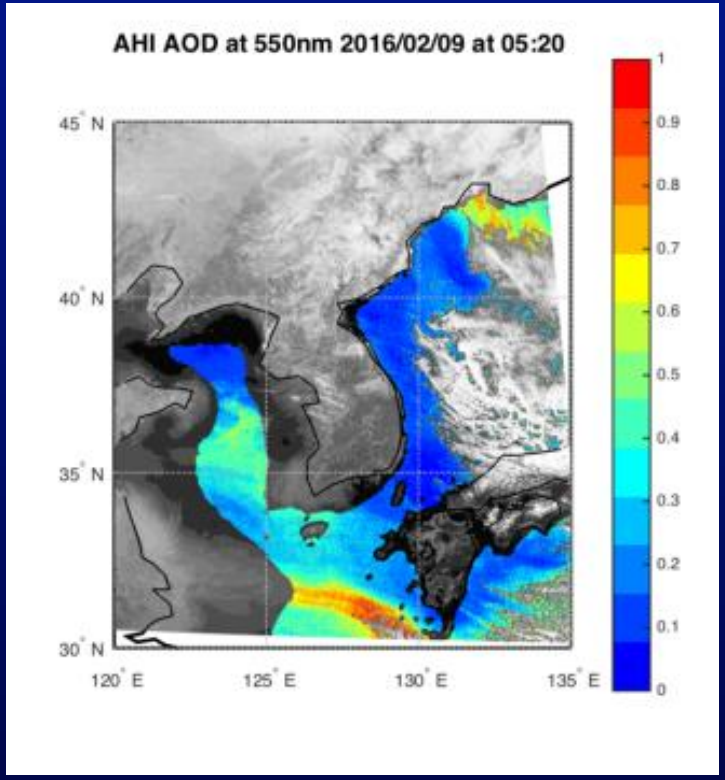
Closing up : The new DoD MURI

Holistic Analysis of Aerosols in Littoral Environments

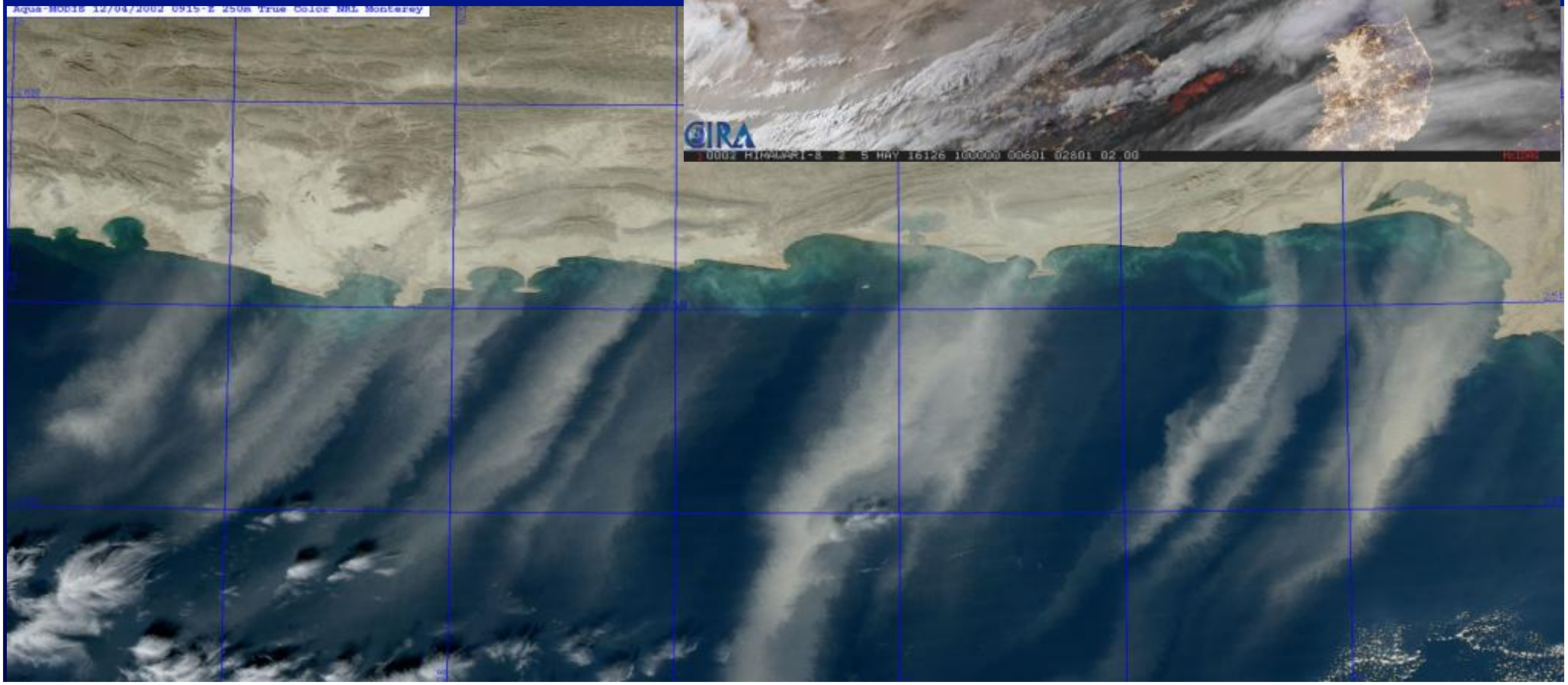
POC: Steve Miller: Steven.Miller@colostate.edu

- Steve Miller of Colorado State CIRA won an open competition for 3-5 year study on aerosol observation and prediction in littoral environments.

- Partners
  - Robert Holz (U Wisc): Geostationary Observations
  - Sonia Kreidenweiss (CSU): aerosol microphysics/radiation
  - Steve Miller(CSU): Synthetic observations
  - Steve Albers(CSU): Model Visualization
  - Sue Van Den Heever(CSU):Mesoscale
  - Jun Wang(U Iowa): Hyperspectral RS
  - Jeromy Solbrig(CSU): Nighttime light sources
  - Jianglong Zhang(UND): Nighttime AOT
  - Milija Zupanski(CSU): Data assimilation



The MURI problem in a nutshell….



Summing Up

- NAAPS News: NAAPS reanalysis updates including Anthropogenic/Biogenic Fine (ABF) getting transitioned
- COAMPS: Now has NAAPS speciation
- Data assimilation:
  - Have NAAPS reanalysis published
  - Have EnKF MODIS published
  - Working on AERONET (See Juli's talk in 2 days…)
  - Next? Single point experiments (Dogpile on HSRL?)
- Science
  - Taking it to the vertical
  - IR systems
  - Extreme biomass burning events
- The MURI is a good focal point for collaboration.