

# 2015 NRL Aerosol Overview

Anthony Bucholtz	Radiative measurements & tactical decision aids
James R. Campbell	Surface and space lidars
Cynthia A. Curtis	Products, distribution & transitions
Edward J. Hyer	Satellite data quality & biomass burning
Steve Lowder (SAIC)	Algorithm development
Peng Lynch (CSC)	Reanalysis, multi model ensemble
David Peterson (NRC)	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	Global and regional modeling

Plus Jianglong Zhang's branch office at UND....

**7<sup>th</sup> ICAP Meeting  
Barcelona, Spain**



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

Navy Operational Global  
Atmospheric Prediction System

## NRL Aerosol Analysis and Prediction System

NRL Atmospheric  
Variational Data  
Assimilation System

**NAVGEM/EFS & NAAPS**

- \*Global Coverage
- \*Meso- to Synoptic Scale
- \*1-7d Guidance/ 20d Ensemble
- \*Weather, Aerosols

**COAMPS®**

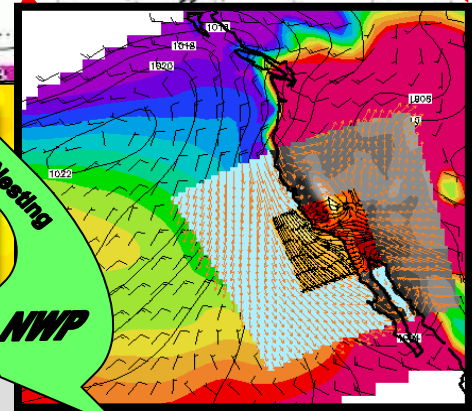
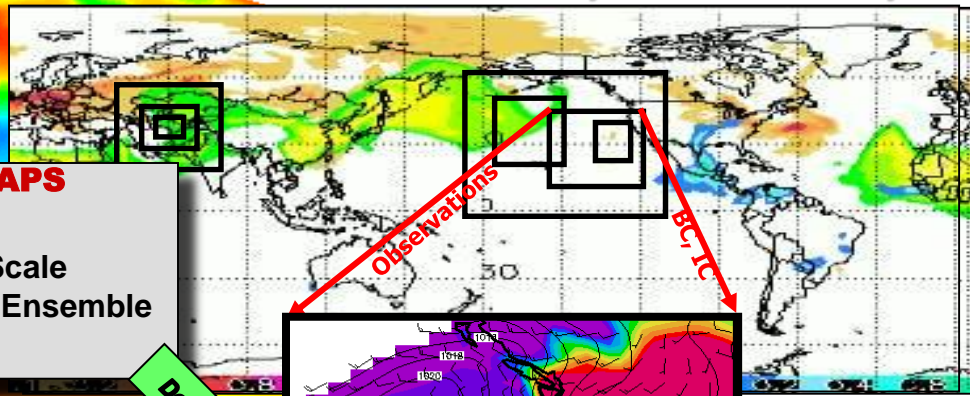
- \*Nested Regional Coverage
- \*Nonhydrostatic Scale
- \*Routine areas, 0-72h Guidance
- \*Weather, Ocean, and Aerosols

**COAMPS-OS®**

- \*Nested Local Coverage
- \*Tactical Scales, tailored products
- \*0-?h Guidance, started on-demand
- \*Ingest localized data for DA

**NOWCAST**

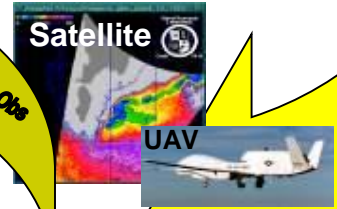
- \*Rapid Environmental Assessment
- \*Warfighter Time & Space Scales
- \*0-6h Guidance, Rapid Update Cycle
- \*Real-time, Automatic, Data Fusion



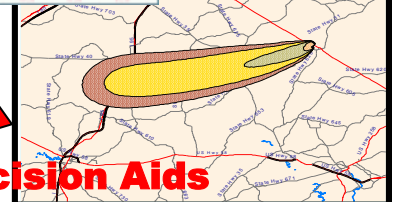
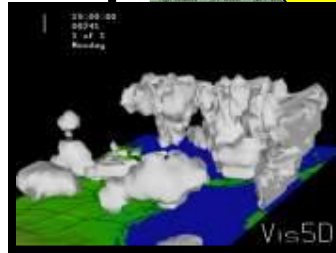
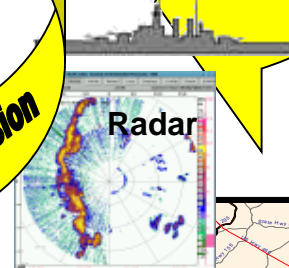
**NAVDAS/  
NAVDAS-AR**

- \*3DVAR / 4DVAR
- \*Radiance Assimilation
- \*Global to Meso- Scale

Through-the-Sensor Obs



Data Fusion



Decision Aids

Coupled Ocean/ Atmosphere  
Mesoscale Prediction System

Down-Scale Nesting

NWP



# Aerosol Product Lines Supported



## Satellite based

- DA grade AOT

- FLAMBE Burning Emissions

## Global Deterministic

- NAAPS Operational (1/3 degree)

- NAAPS Inline

- NAAPS reanalysis (2000+, 1 degree)

## Global Ensemble

- ENAAPS forecast (1 degree)

- ENAAPS DA (1 degree->0.5 degree; 20->80 members)

- ICAP MME (1 degree AOT)

## Mesoscale

- COAMPS Dust

- COAMPS-NAAPS (In development)





# Deterministic NAAPS Efforts



- Complete adaptation and transition from NOGAPS to NAVGEM meteorology.
- Operationally implement bulk pollution over sulfate.
- Develop hybrid version of NAAPS (Open MP and MPI) to reduce wall time.
- Inline development within NAVGEM.
- ENKF Data Assimilation or hybrid with 4D Var



# Navy Global Environmental Model – NAVGEM

## The basis for Navy global aerosol



### Data Assimilation

- **NAVDAS-AR 4D-Var with Variational bias correction**

### NAVGEM 1.3 Upgrades

- **Increased resolution from T359L50 to T425L60**
- **New stratospheric physics for water vapor photo chemistry, sub-grid-scale non-orographic gravity wave drag, and stratospheric humidity quality control**
- **New dynamics formulation utilizing perturbation virtual potential temperature to improve numerical stability and reduce semi-implicit decentering**
- **Convective cloud fraction predicted based on Xu-Randall**
- **Improved initialization of ground wetness and temperature**

### Future Upgrades

- **Short Term: dynamic sea ice (CICE) model via ESMF coupling, T681L80: (~19 km) and 0.01 hPa model top**
- **Longer Term: ~10 km resolution, interactive aerosols, coupled atmosphere-ocean-ice-wave extended-range prediction system**



# ENAAAPS DA

(See Juli Rubin's talk)

- The immediate customer for ENAAAPS is EnKF data assimilation technologies.
- NCAR-DART has been implemented and a base configuration developed.
- EnKF on the NAVGEM ensemble is a contender for operations.
- Bottom lines
  - Need source and meteorology draws
  - 20 members “does no harm,” 80 members better.



# ENAAPS



## Probabilistic Development

- 20 NAVGEM members truncated to 1x1 degree with a 6 day forecast made daily.
- Sort of in Neutral-waiting for NAVGEM ensemble developments

T+ HOUR
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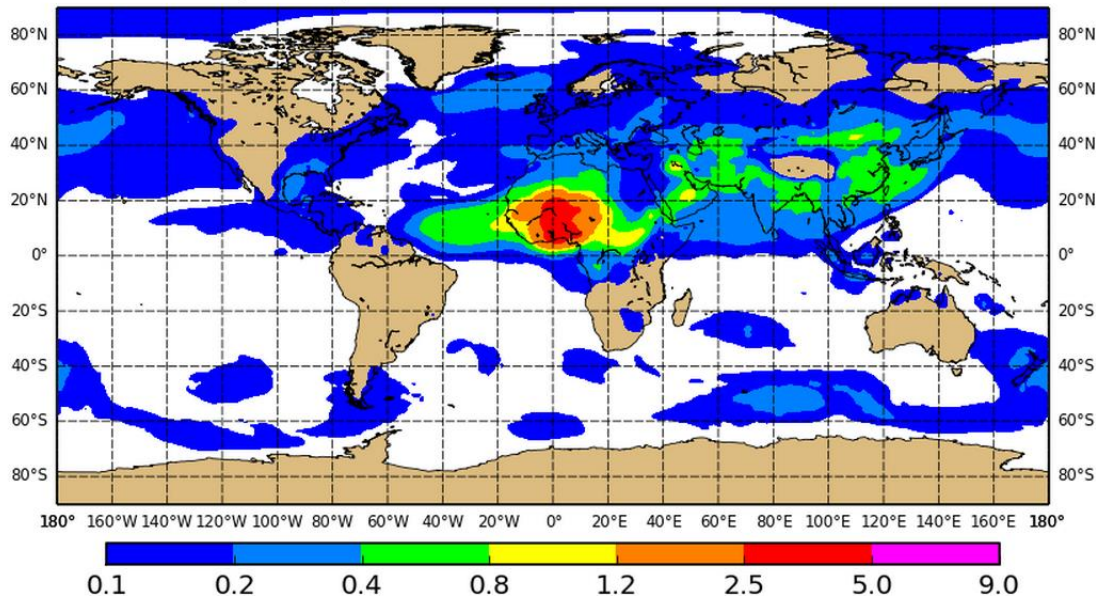
sulfate
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byzantium
eastasia
subtropatl
pacific
conus
satlantic
sioaus
npolar

[http://www.nrlmry.navy.mil/aerosol/ens\\_date.php?date=latest&field=aod&spec=total&regc=global](http://www.nrlmry.navy.mil/aerosol/ens_date.php?date=latest&field=aod&spec=total&regc=global)

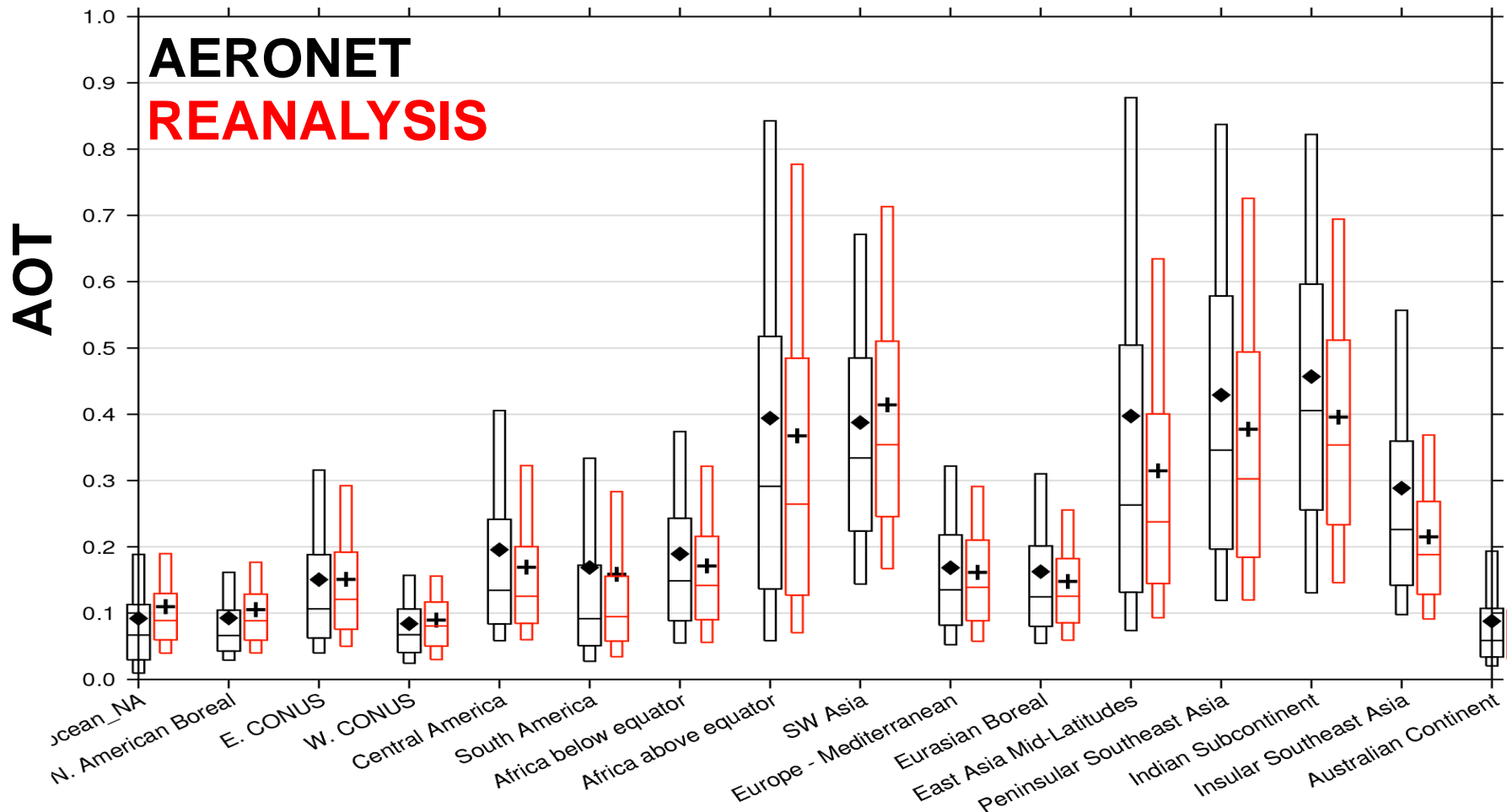
Thursday 9 April 2015 00UTC ENAAPS-NAV Forecast t+120  
 Tuesday 14 April 2015 00UTC Valid Time  
 TOTAL Aerosol Optical Depth at 550nm ( nMEM = 20 )



Plots Generated Thursday 9 April 2015 23UTC NRL/Monterey Aerosol Modeling  
 NOT OFFICIAL FNMOC NAAPS RUN

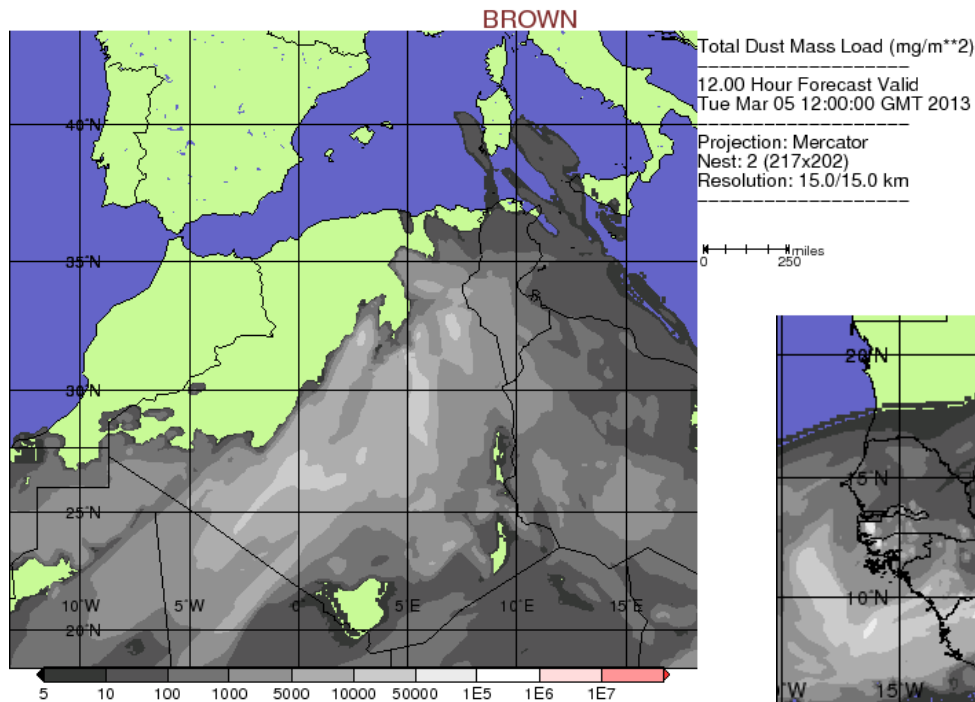
# NAAPS Reanalysis

The 2000-current NAAPS reanalysis was generated to allow for flexible aerosol science and provide a baseline for verification over many field campaigns. AOT fields are now on the GODAE server.



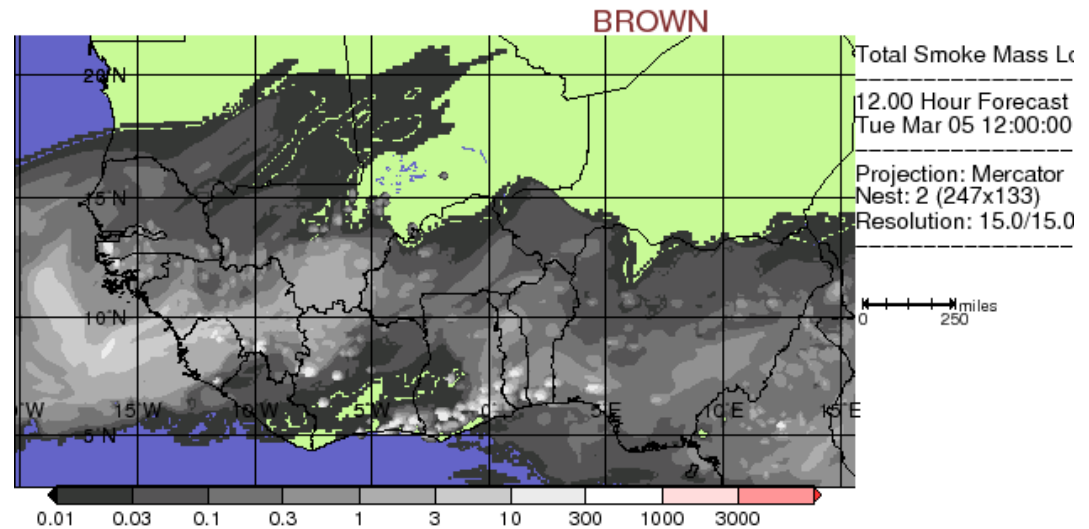


- Dust has been operational since 2000 ish.
- New upgrade to make COAMPS much more NAAPS like.



Dust

**BROWN**



Biomass Burning Smoke

**BROWN**



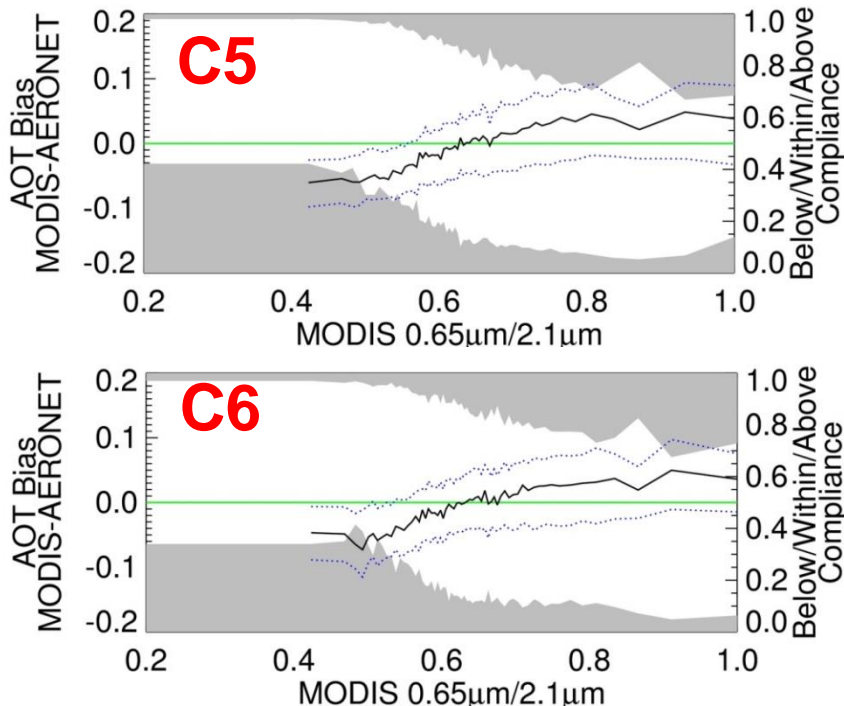
# Remote Sensing



- Next Gen Aerosol DA products
  - MODIS Col 6 Terra & Aqua are both here. Starting systematic analysis.
  - Hope to use MODIS Col 6 ported to VIIRS.
  - Waiting game for MISR and GRASP data.
  - Question for GSFC, where is NN going?
- Fire
  - Next gen multi satellite.
- Lidar
  - How do we use this data, really?

## MODIS Collection 6 – upgraded MODIS L1-L2-L3 products

- Collection 6 changes include algorithm changes and new sensor calibration
- As of 3/17/2015, C6 processed by NASA through June 2014
- QA/QC processing algorithms in development at NRL

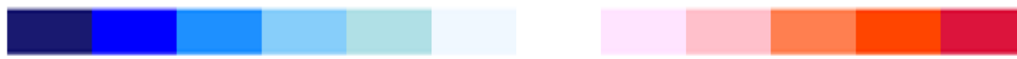
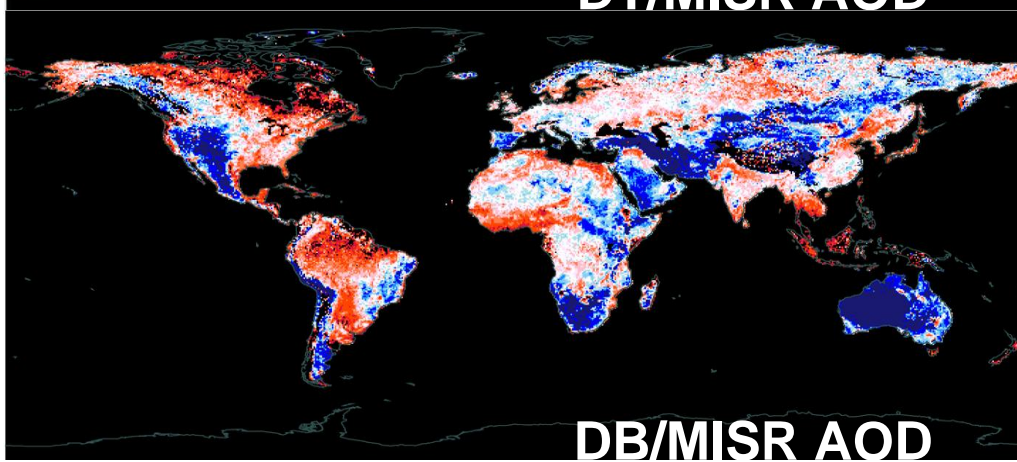
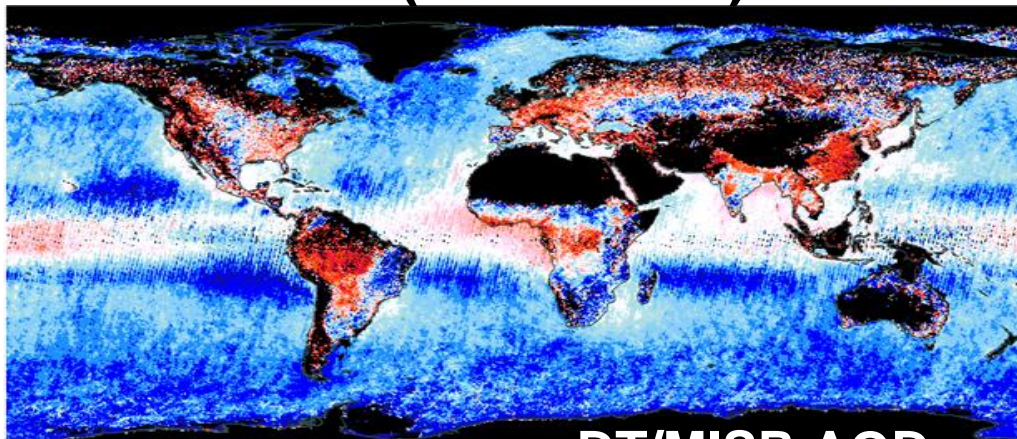


- **Collection 6 has modified surface reflectance estimation, but biases remain– empirical correction must be recomputed**
- **Albedo thresholds in QA/QC will be revisited: Collection 6 includes “Deep Blue” alternate algorithm for use over bright surfaces (urban/desert)**

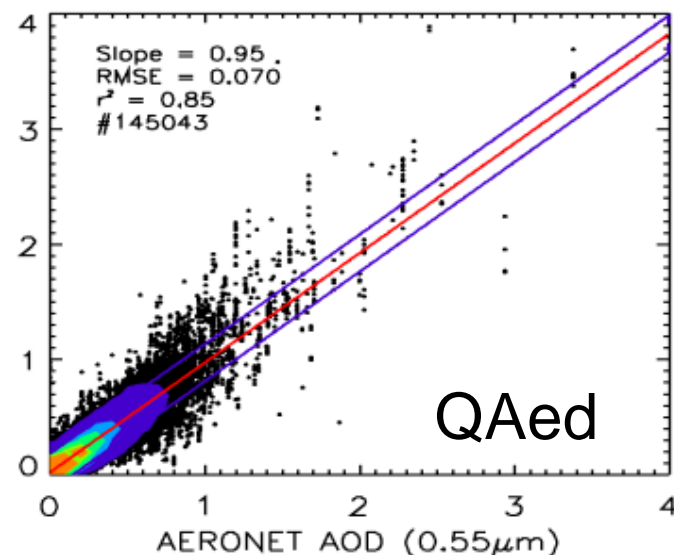
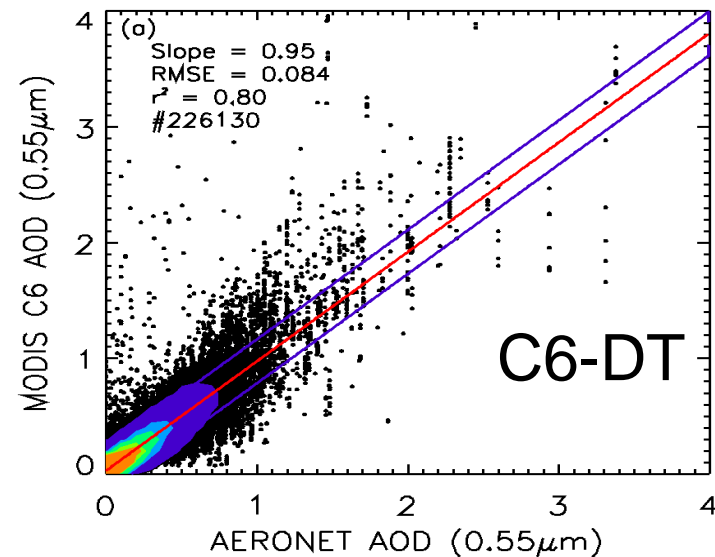


# In depth evaluation of satellite aerosol products for DA

## 2005-2007 (C6 MODIS)

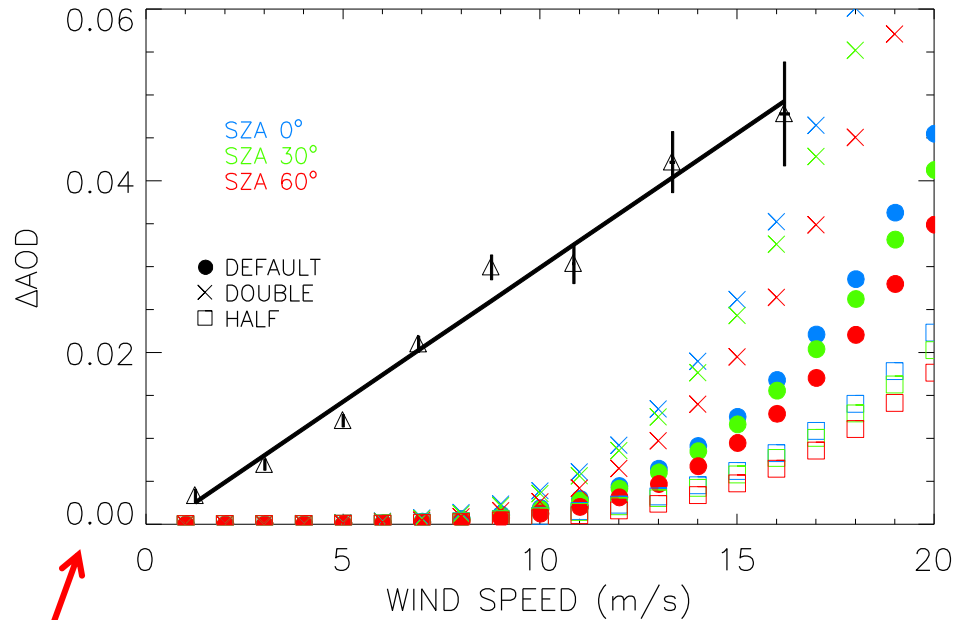
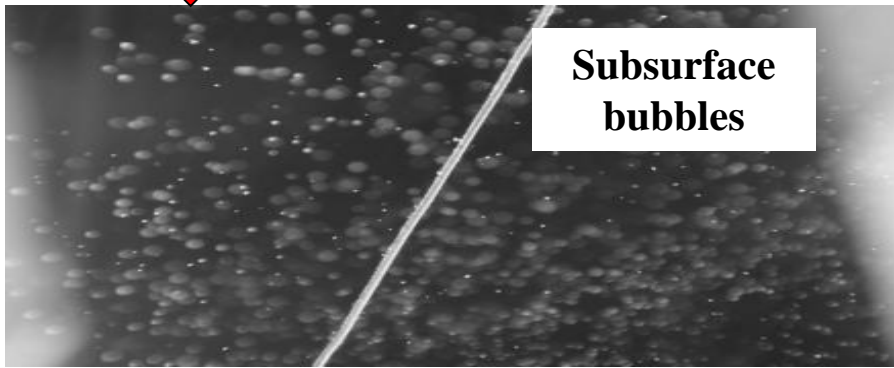
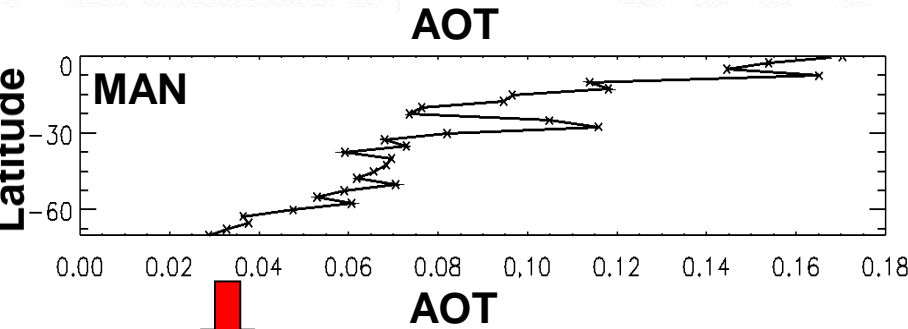
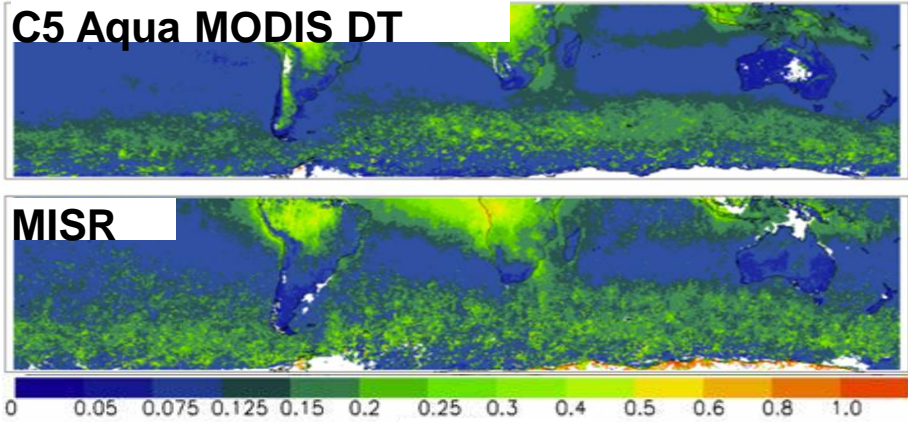


0.4 0.6 0.7 0.8 0.9 1.11 1.25 1.66





# In depth evaluation of satellite aerosol products for DA (ESOA)

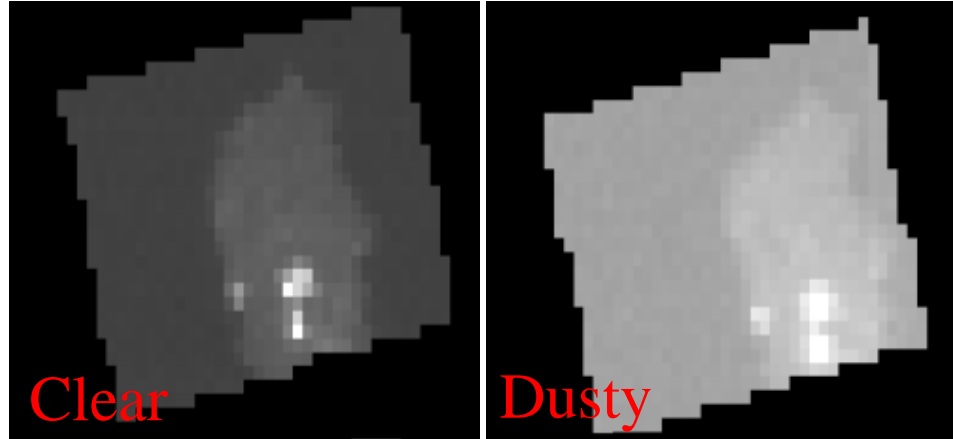


- Subsurface bubbles may not be important for AOT under low wind speed conditions (less than 12 m/s), but it has been shown its importance for TOA energy and ocean color retrievals
- Significant for aerosol retrievals for high wind speed cases.

# Developing a new nighttime dataset for DA

- Artificial light sources can be used, as an inverse AERONET technique for nighttime AOT retrievals
- An potential data source for DA

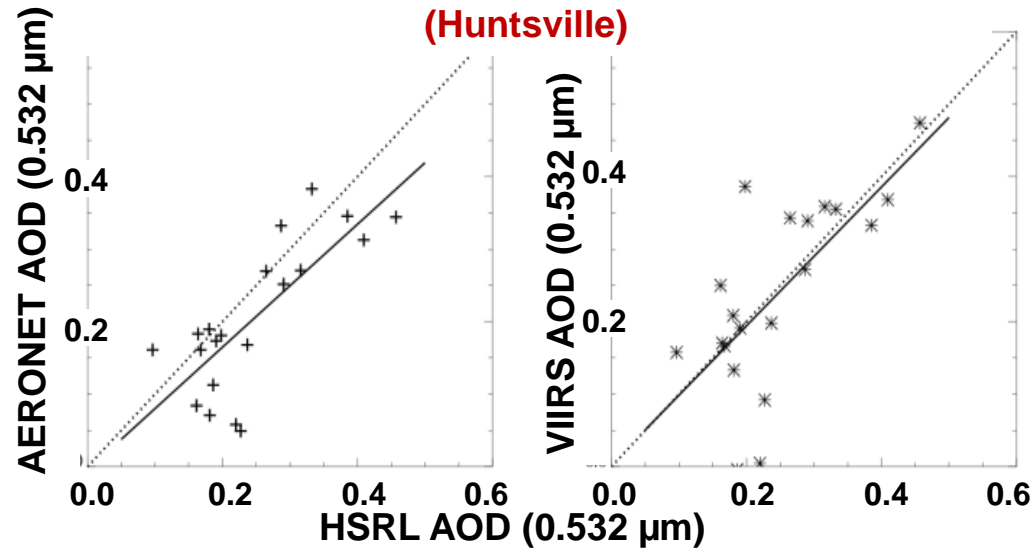
## Cape Verde, clear versus dusty skies

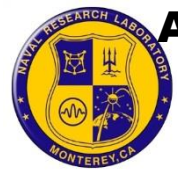


Nighttime city lights (figure obtained from NASA)



## VIIRS DNB and AERONET AOD vs. HSRL AOD (Huntsville)

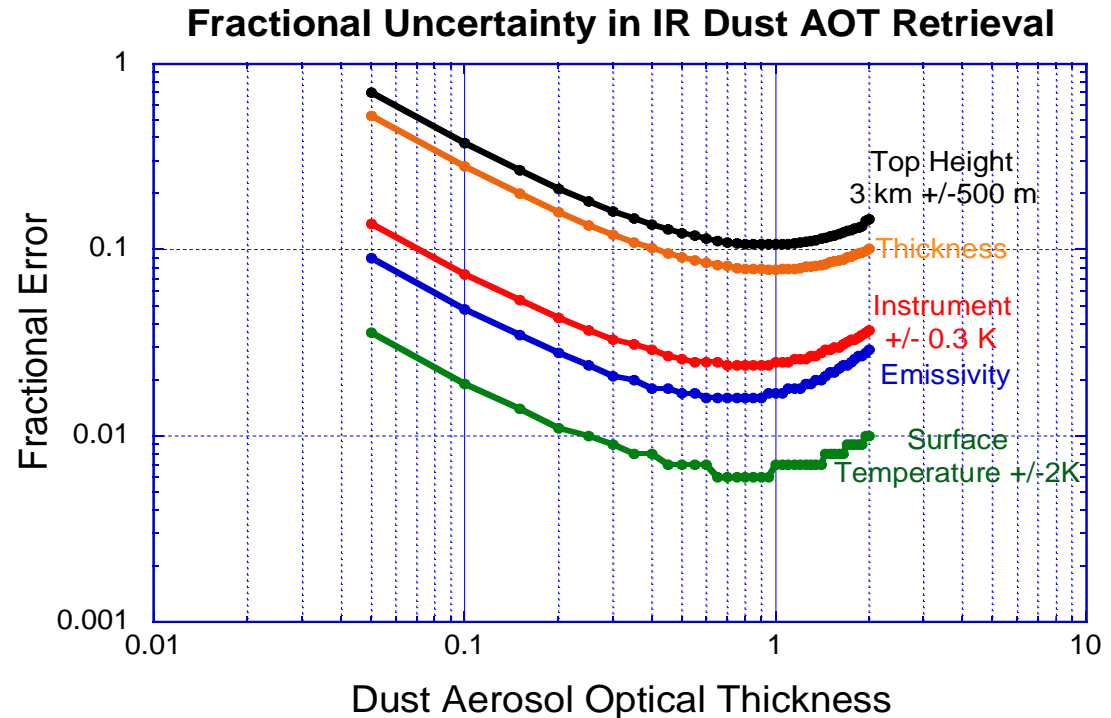




# Application of deterministic framework for meteorological data assimilation Joint U. Wisconsin IR-Dust Example

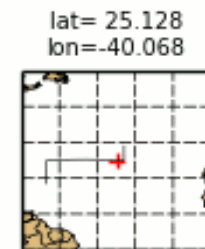
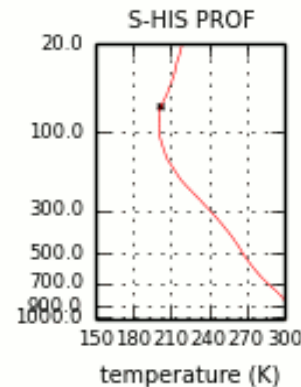
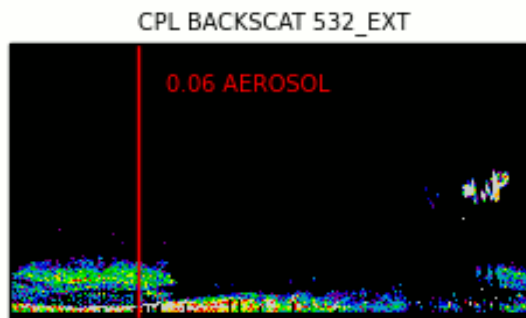
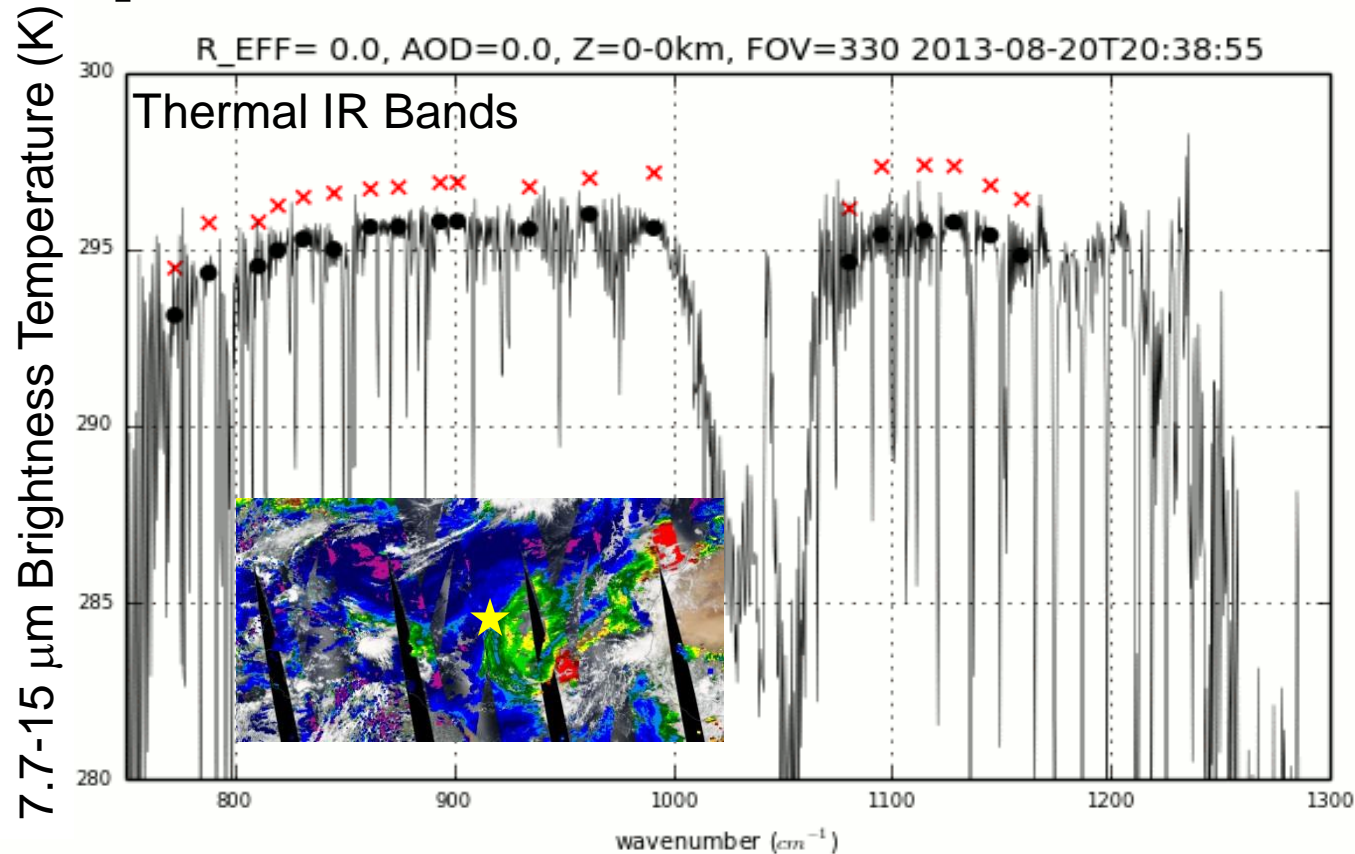
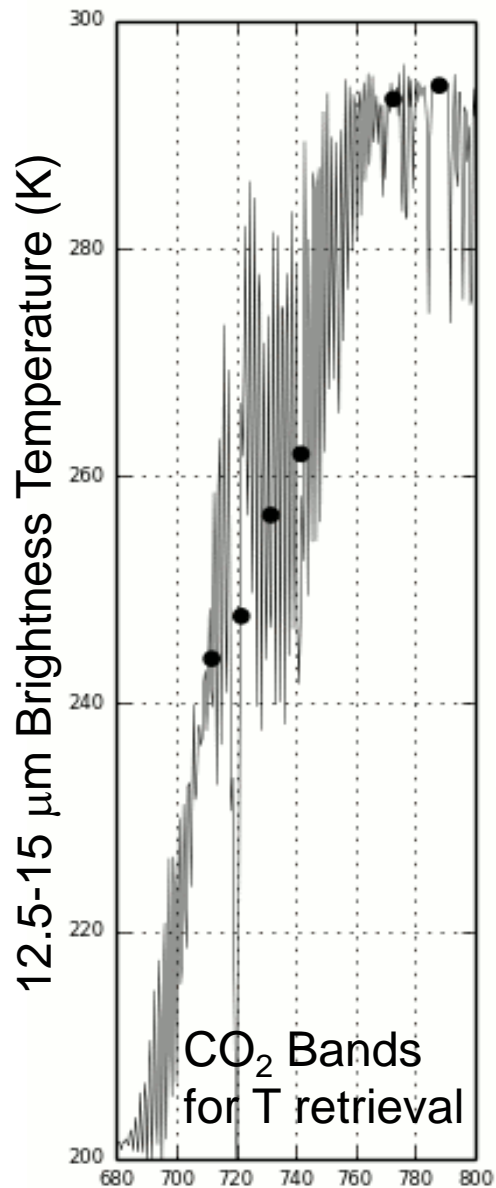


- Rationale: Need an interesting problem to pull all of the aerosol, remote sensing and meteorology pieces together. Dust in the IR fits the bill.
- Partner: This supports W. Sessions' Ph.D. at Wisc.
- How: Use the HS3 Global Hawk Scanning-HIS, Cloud Physics Lidar and dropsonde dataset to build an end to end measurement and modeling framework.
- Benefit: Real world tractability of uncertainty propagation



Properly constraining the vertical characteristics of aerosol layers is of primary importance. SSEC currently produces a dual-regression layer height retrieval which we use as part of the a priori state, providing a single sensor solution for comparison to the model.

# Example HS3 Dust Plume Transit Impact on IR:4°C perturbations due to dust



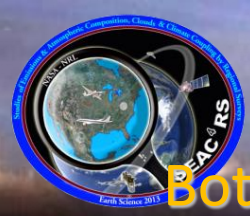




# Relevant field work efforts

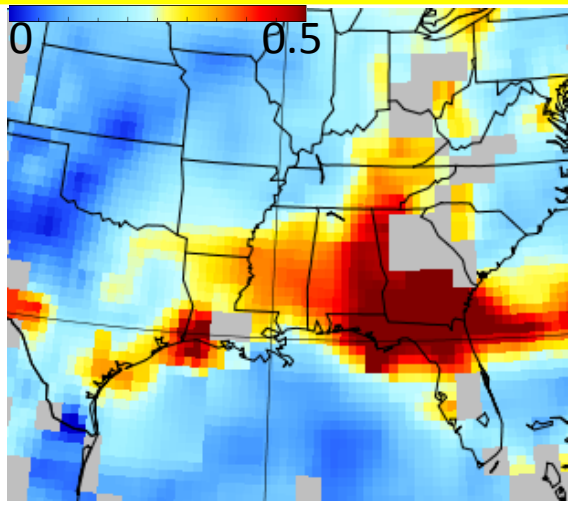
## Let us know if you would like to play

- SEAC4S analysis: If you have vertical profiles of aerosol and met data at a few sites, it would be good to examine error propagation from AOT to particulate matter.
- Significant effort with U of Wisconsin on “What does lidar data mean anyway and what is the best way to assimilate it?”
- Mid 2017 to mid 2019 will likely see a great deal of Se Asian focus in the community in association with CAMPEX, PISTON and the “Year of the Maritime Continent”

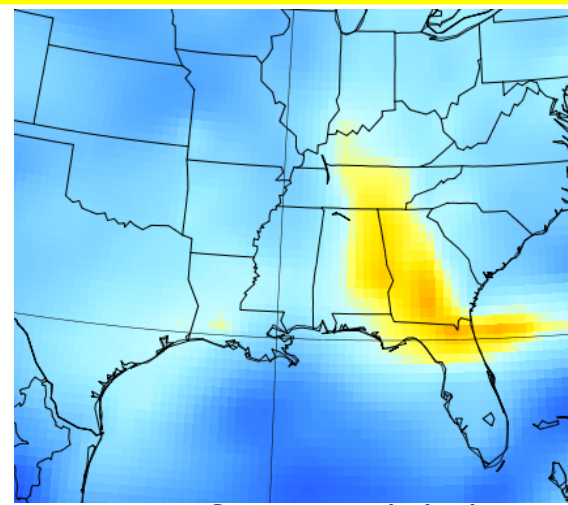


# Aug 30: Flavors of NAAPS

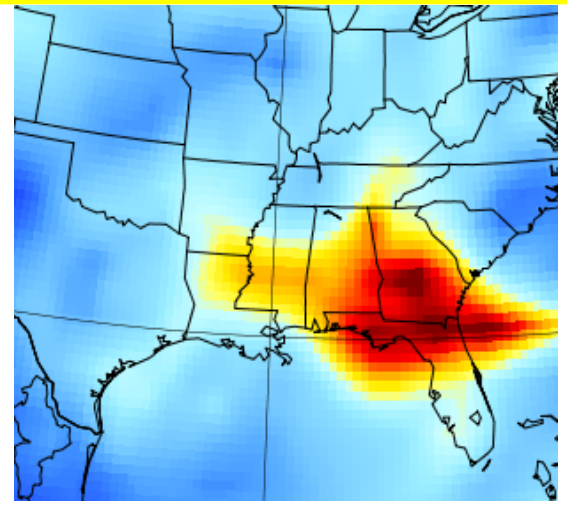
Both chemistry and meteorology at work in a good prediction



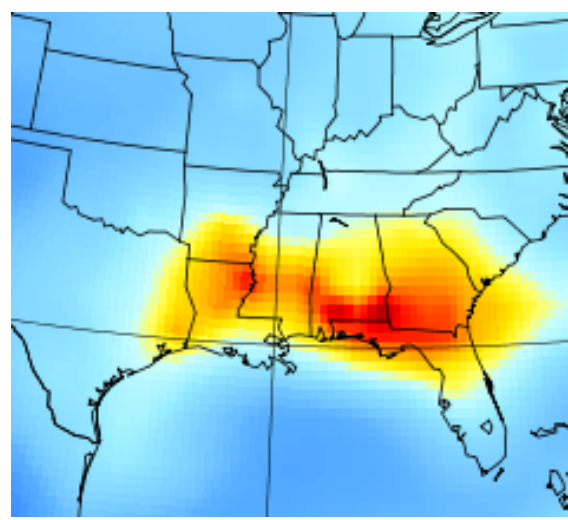
MODIS Combined AOT



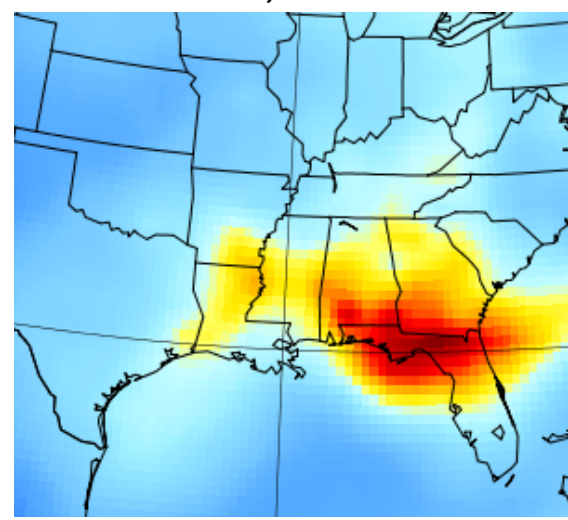
NAAPS Deterministic  
OZ run, Valid 18z



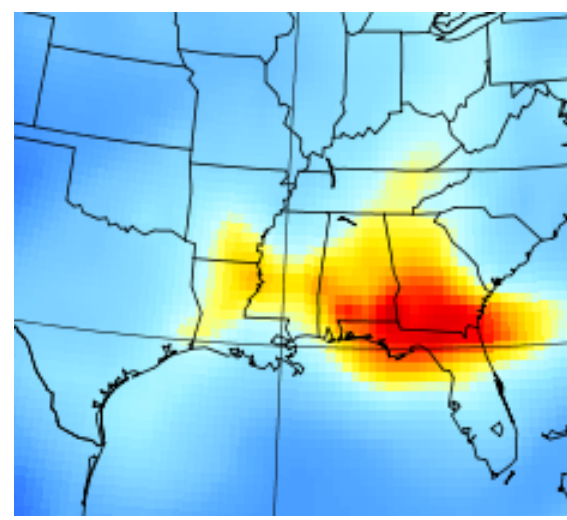
NAAPS AOT Reanalysis



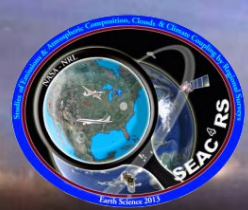
E-NAAPS 20 member  
OZ run, Valid 18z



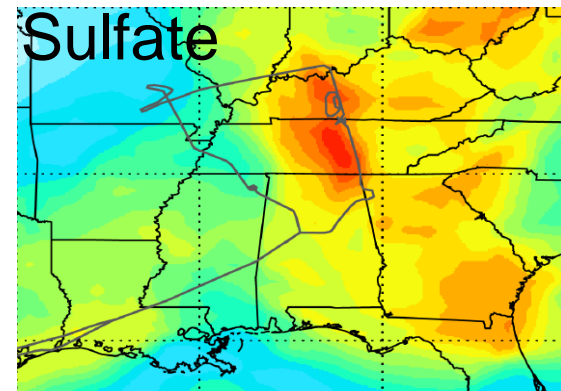
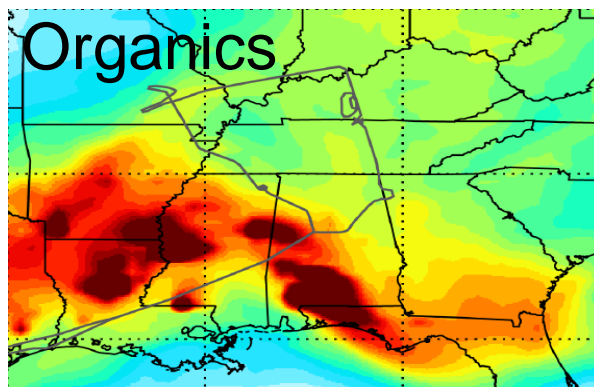
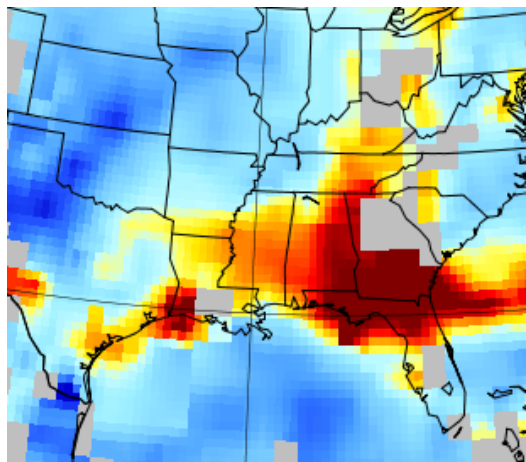
E-NAAPS 20 member  
18Z run, Analysis



E-NAAPS 80 member  
18Z run, Analysis

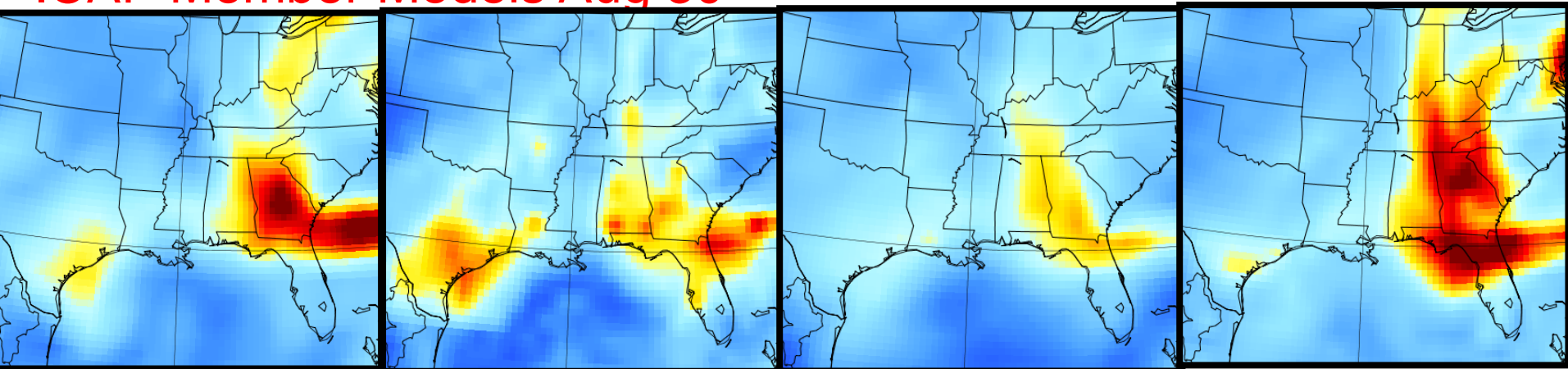


# Aug 30. Model comparison

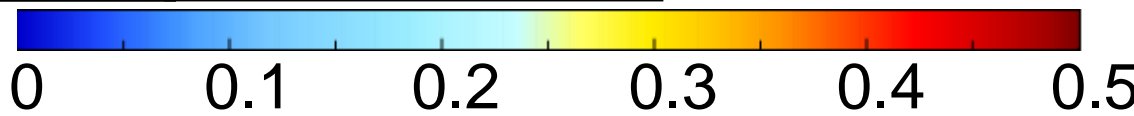


MODIS Combined AOT GEOS Chem 24 hr Surface Concentrations ( $\mu\text{m m}^{-3}$ )

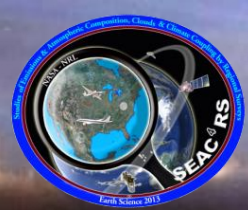
## ICAP Member Models Aug 30



550 nm AOT







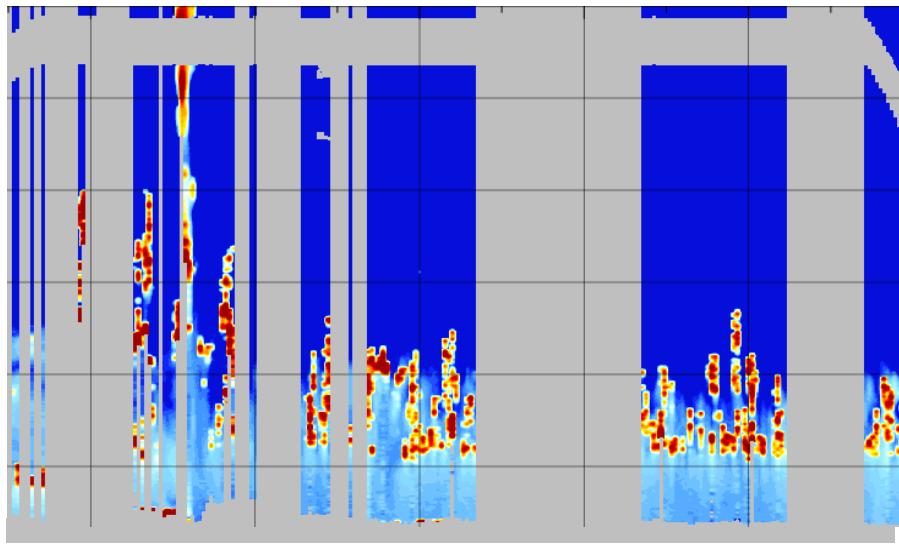
# Moving on to the vertical

We need to make sense of multiple points of view.

Joint NRL, Wisc, LaRC

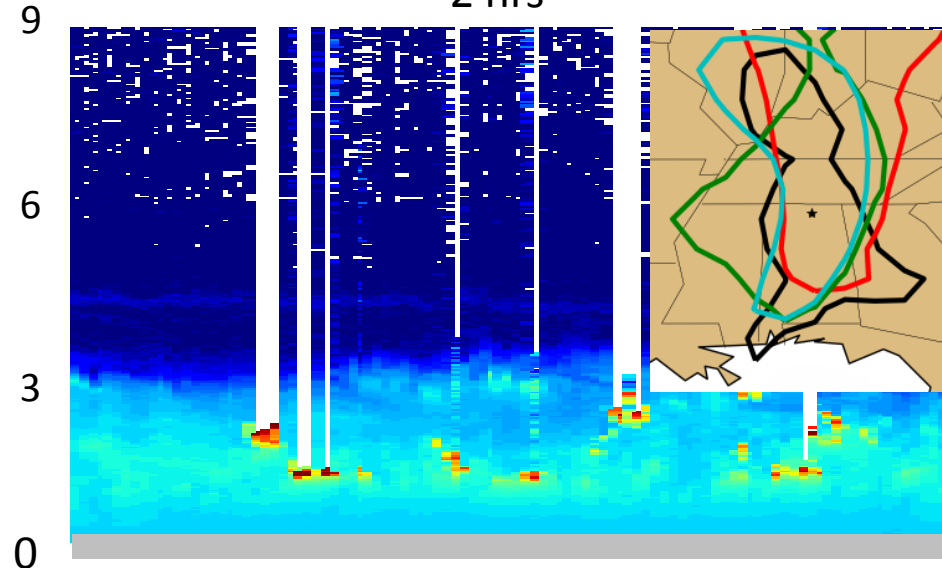


SEUS Average Airborne HSRL Profile  
South to North ~ 400 km

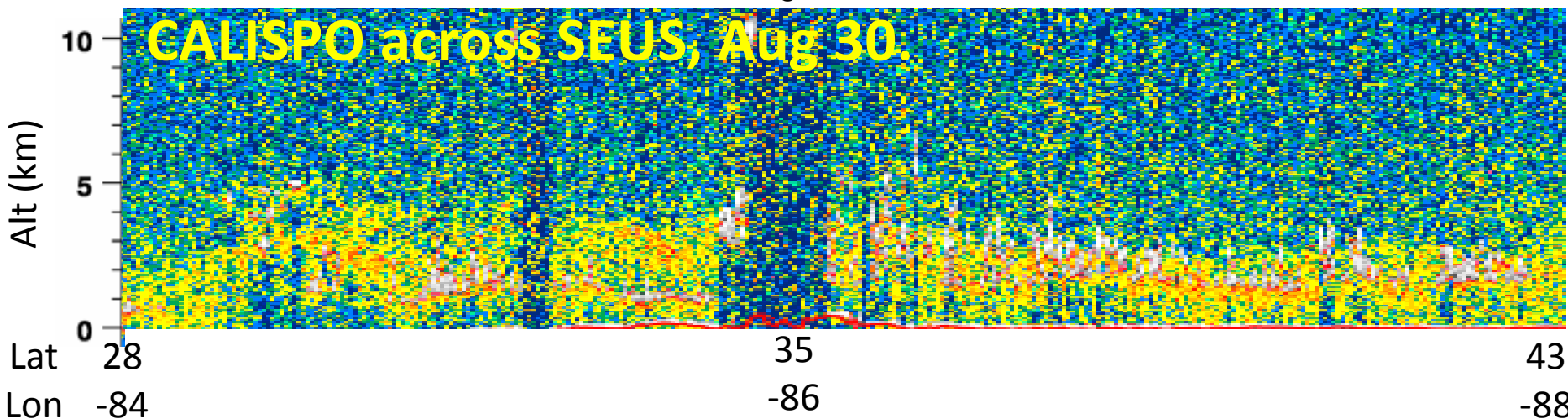


Alt  
(km)

SSEC HSRL deployment to Huntsville  
~2 hrs



CALISPO across SEUS, Aug 30.





# Cloud-Aerosol-Monsoon Philippines Experiment

## CAMPEX

### 6.1 Measurements

#### Overview:

- **Funding Agency:** NASA
- **Proposed Dates:** Aug-Sept 2018
- **Locations:** Subic Bay Philippines, South China, Sulu, Celebes Seas &, WestPac
- **Platform:** NASA P3



#### Scientific Objectives:

- 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; c) freshwater flux to the oceans

#### Whitepaper Participation:

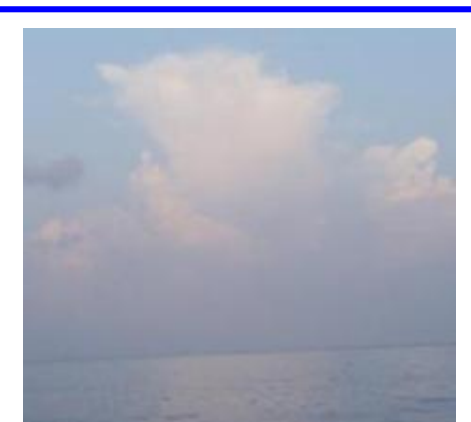
- Di Giralamo (UIUC)-Clouds & Radiation, Holz (SSEC-UW) Remote Sensing, Reid-Aerosol lifecycle and interdisciplinary science, Tanelli (JPL)- Precipitation, van der Heever (CSU)- convection

#### Applications:

- Research on clouds and littoral meteorology in a strategic interest area
- Aerosol impacts on numerical weather prediction
- Collaboration with ONR PISTONS and YMC



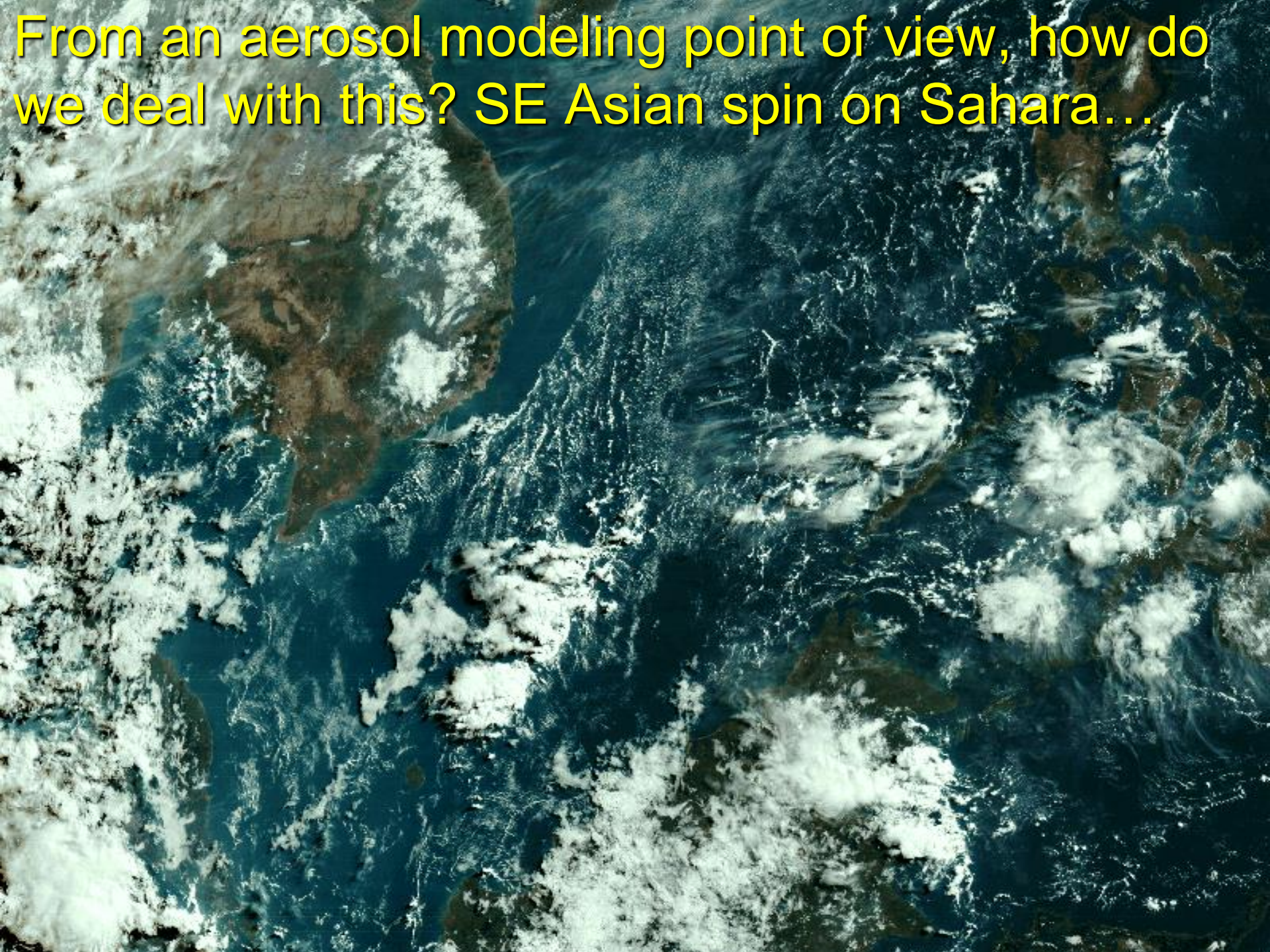
Pristine Conditions



Polluted Conditions



From an aerosol modeling point of view, how do we deal with this? SE Asian spin on Sahara...







# Summary & Closing Thoughts



- Lots of flavors of NAAPS. Pretty soon there is going to need to be some consolidation.
- Future NAAPS efforts towards inline, higher resolution.
- ENKF is a contender for DA (See Juli' s Talk)
- COAMPS is looking a lot more like NAAPS.
- Remote Sensing: Progress marches on. I see more evolution than revolution in the immediate future. But near global geostationary is looming.
- Field work: Looking for systematic representation bias. SE Asia will continue to be a big part of our future. 2016 another push on sea salt?