ARL
Air Resources Laboratory
Conducting research and development in the fields of air quality, atmospheric dispersion, climate, and boundary layer

Trace gas applications for air quality

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Matthew Alvarado[6]

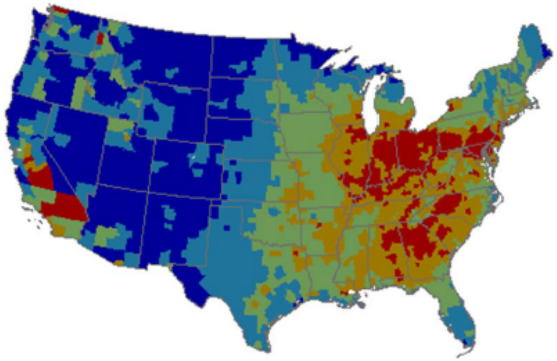
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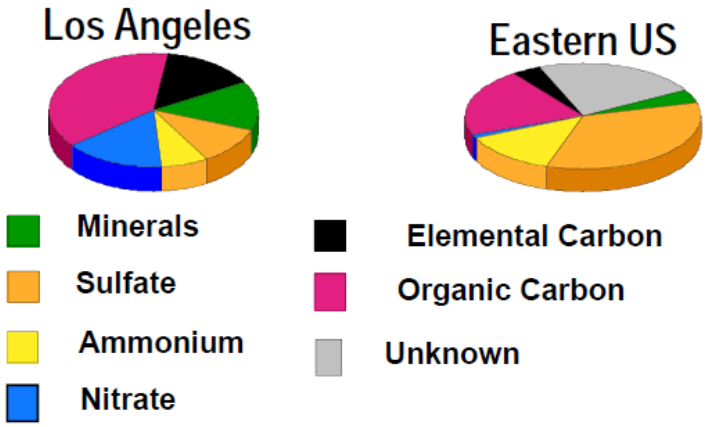
Courtesy: Dan Costa
"New Directions in Air Quality Research at the US EPA"

Public Health Burden of $PM_{2.5}$

(Fann et al., 2011)

Percentage of $PM_{2.5}$ related deaths due to 2005 air quality levels by county

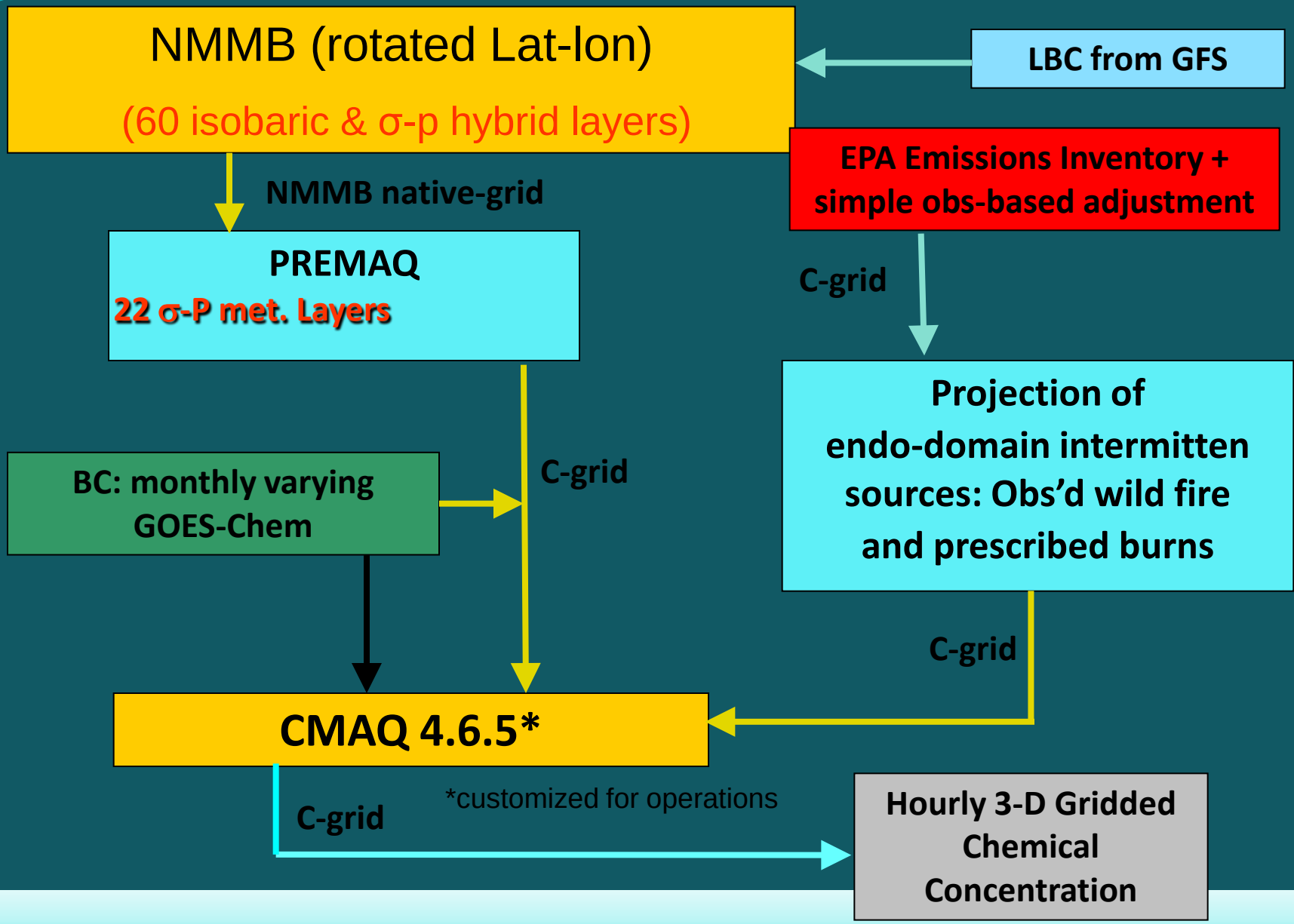




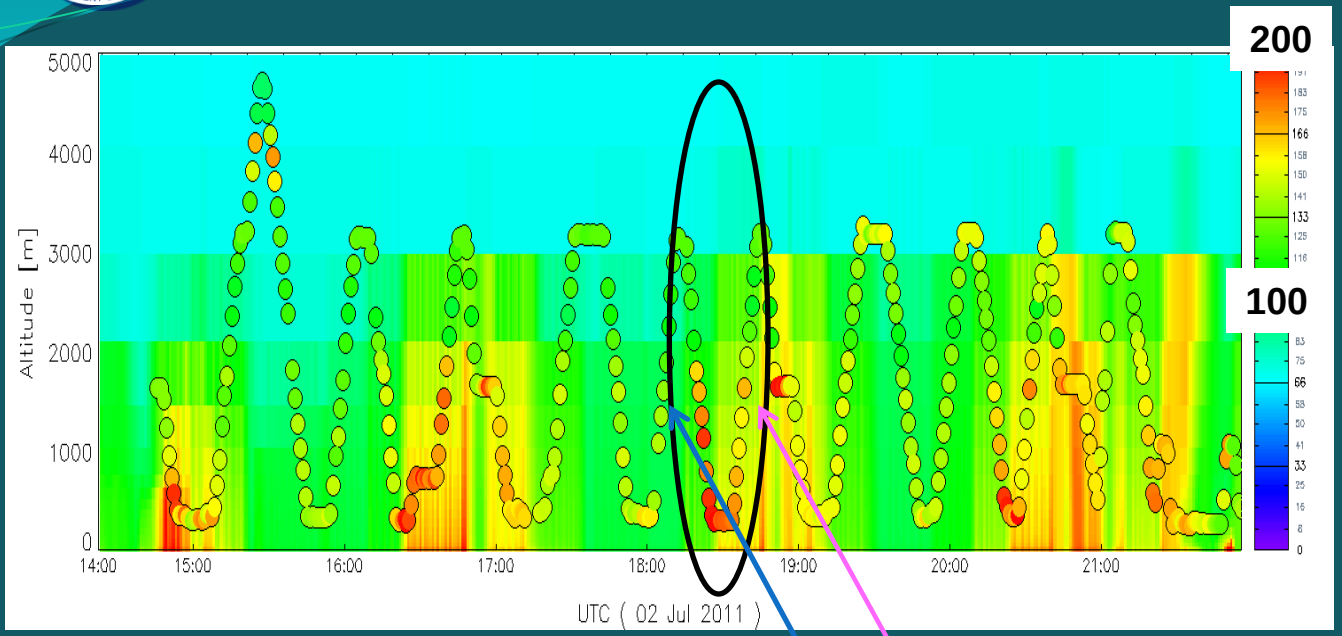
Summary of National $PM_{2.5}$ impacts due to 2005 air quality	
Excess mortalities (adults)[A]	130 to 320,000
Percentage of all deaths due to $PM_{2.5}$[B]	5.4%
Impacts among Children	
ER visits for asthma (<18 yr)	110,000
Acute bronchitis (age 8-12)	200,000
Exacerbation of asthma (age 6-18)	2,500,000

[A] Range reflects use of alternate PM mortality estimates
[B] Population-weighted value using Krewski et al. (2009) PM mortality estimates

NAQFC: NMMB-CMAQ



CO (ppb) along the P3 Flight – July 2 2011: AOD_DA case vs. Obs



P3 Three and a half loops:

Beltsville

Padonia

Fairhill

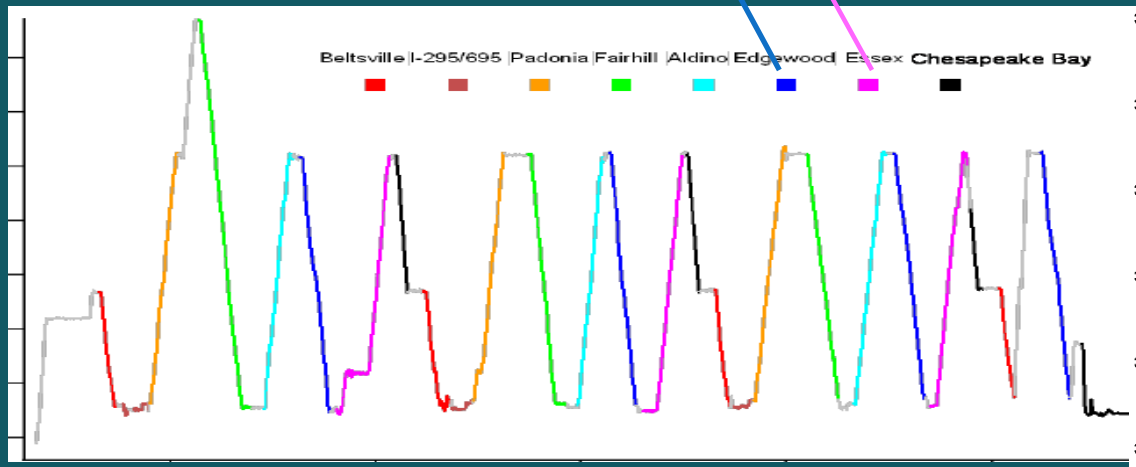
Aldino

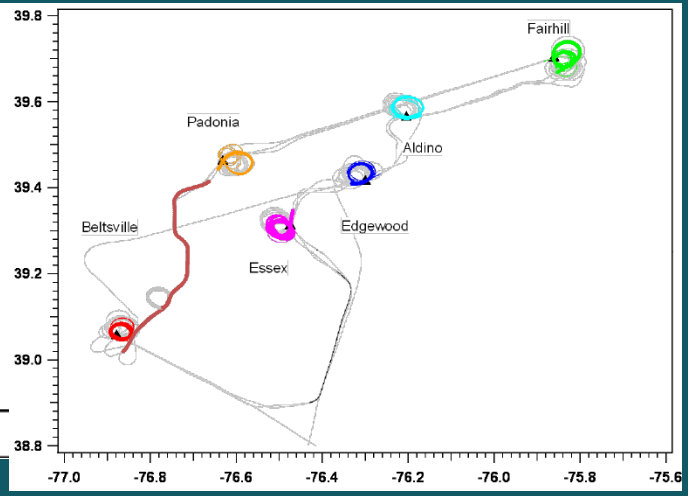
Edgewood

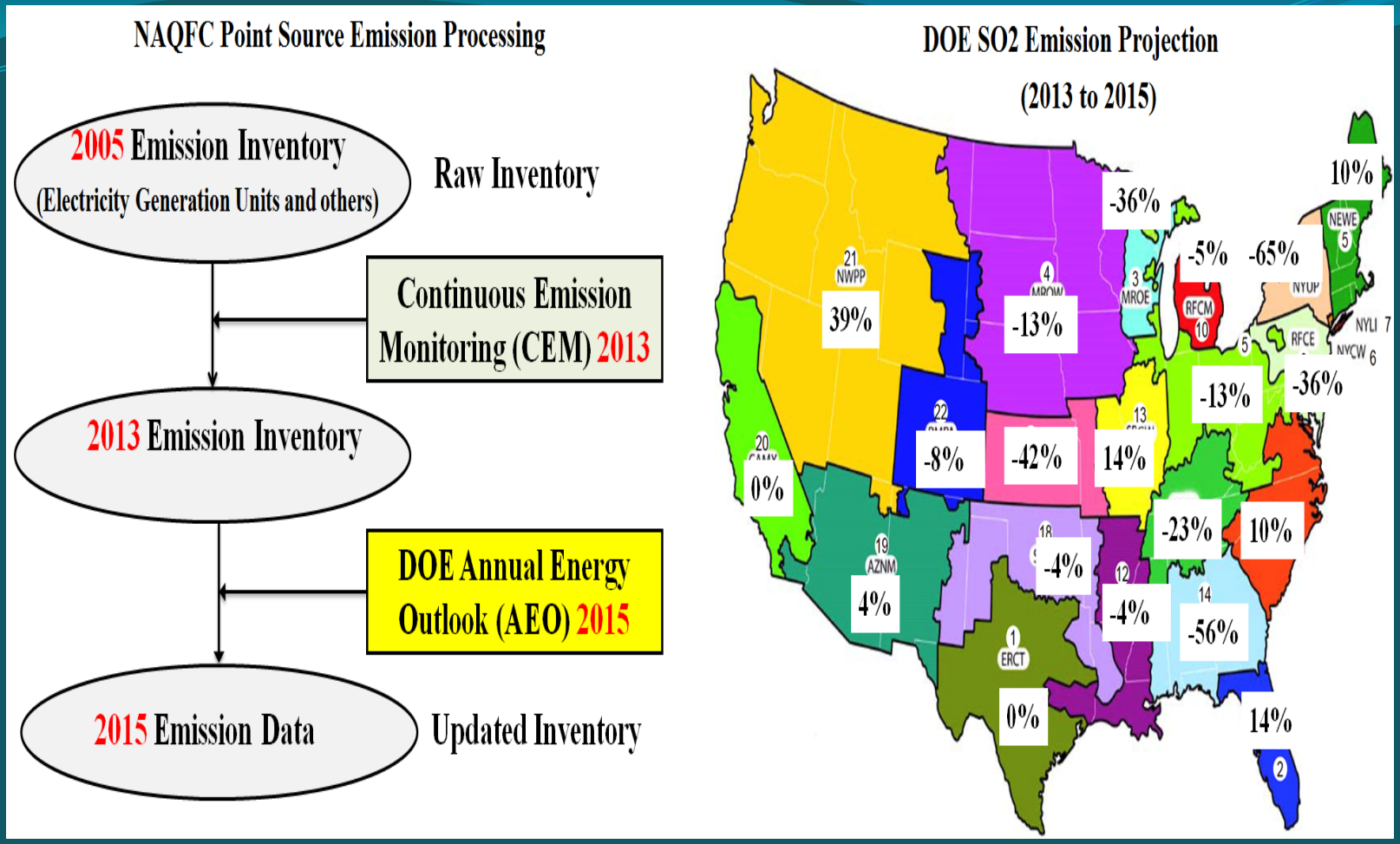
Essex

Chesapeake Bay

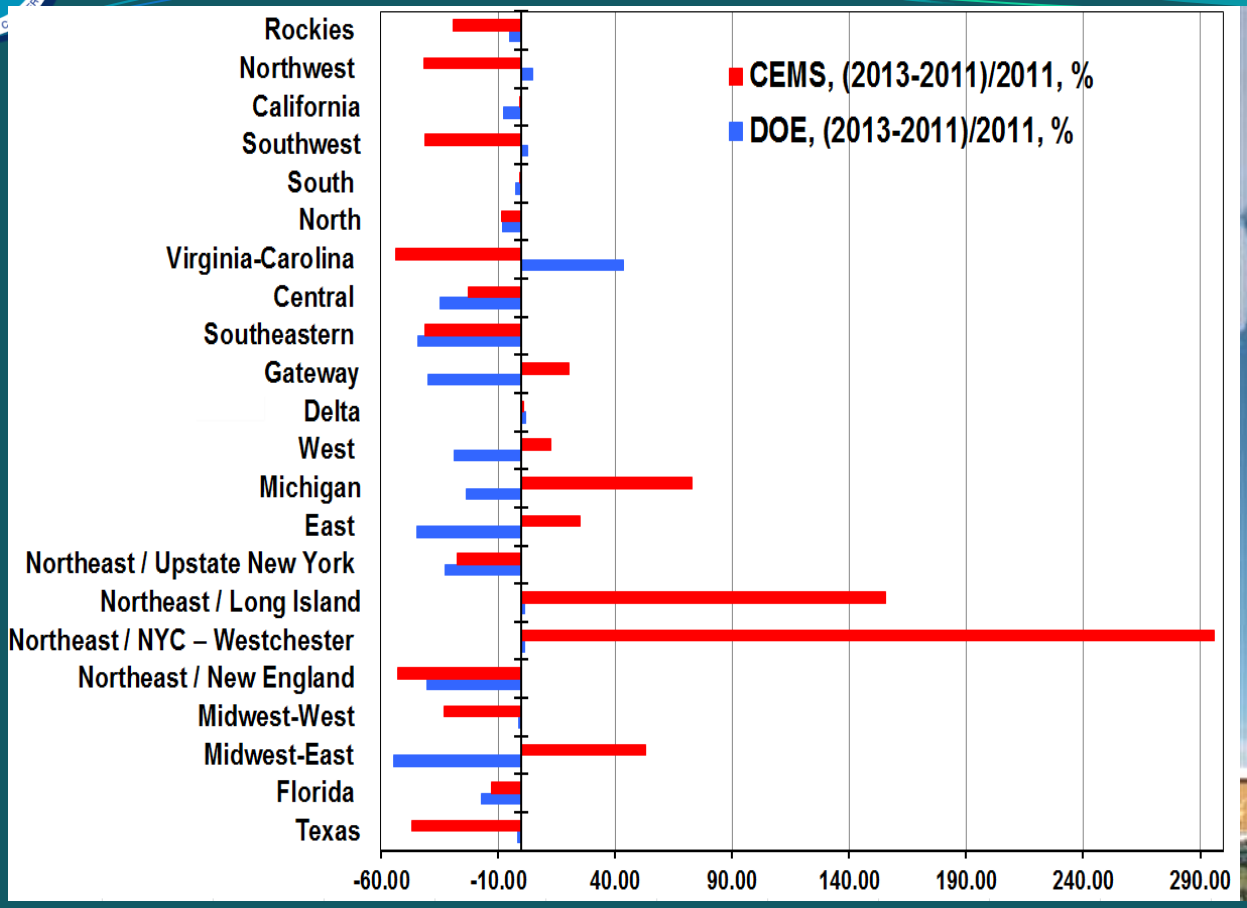






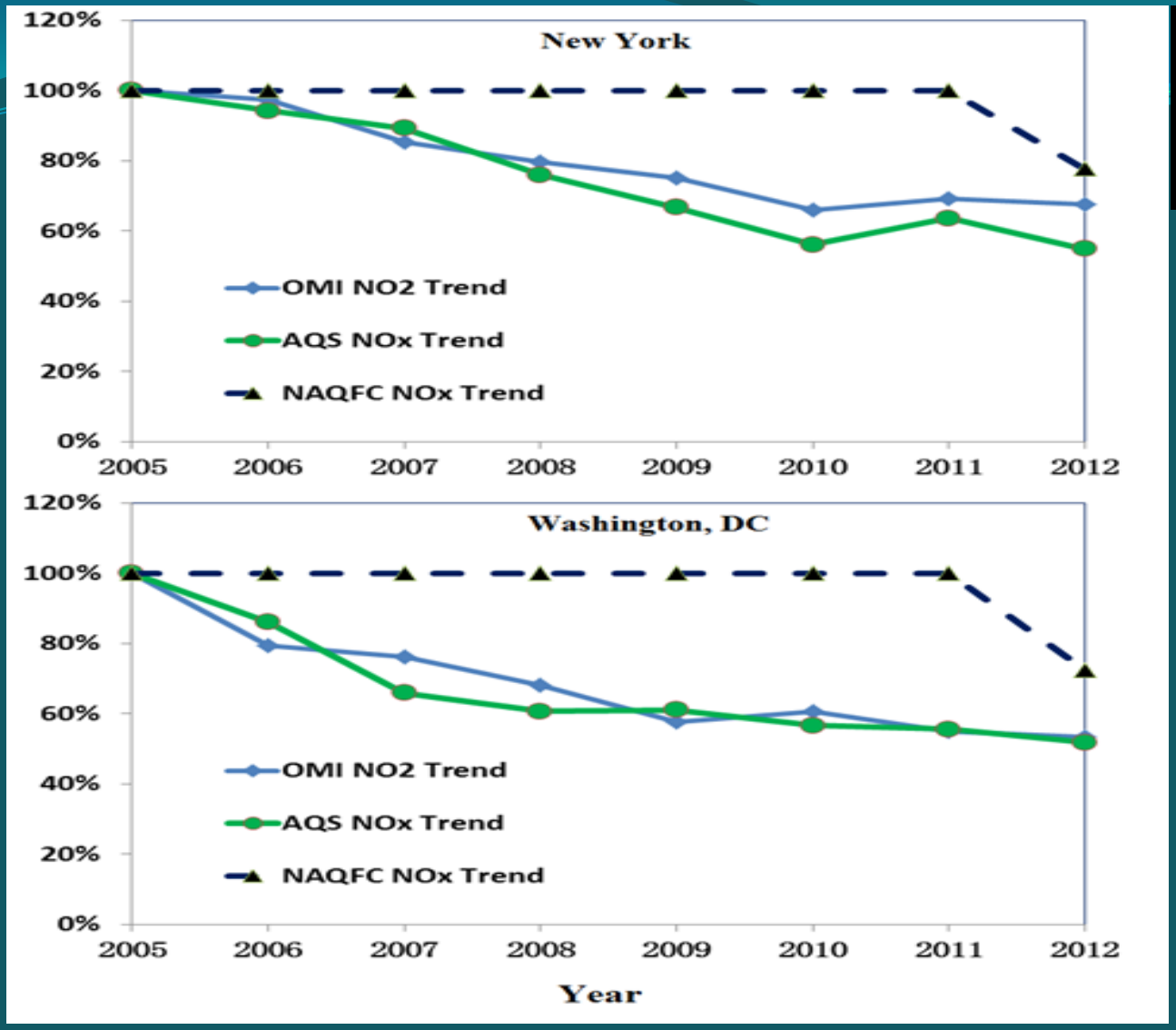


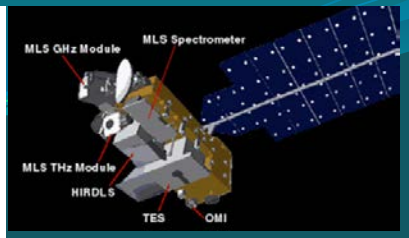
Current approach useed by NAQFC to update power plant emissions (left) and DOE projection factors for FY 2015 operation (right).





Comparison of DOE projected changes and CEM observations from 2011 to 2013 in 22 EMMs

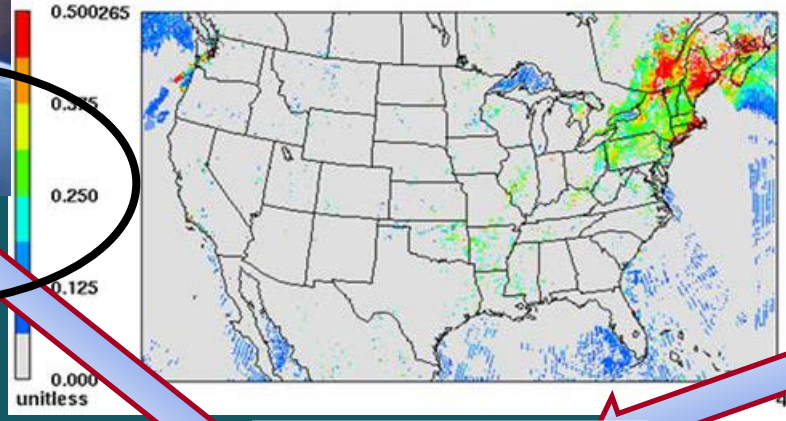




Rapid refresh of NOx emission projection in NAQFC
Comparison of satellite (OMI), ground (AQS) and NAQFC model NOx emissions in New York and Washington, DC from 2005 to 2012 (Tong et al., 2015).

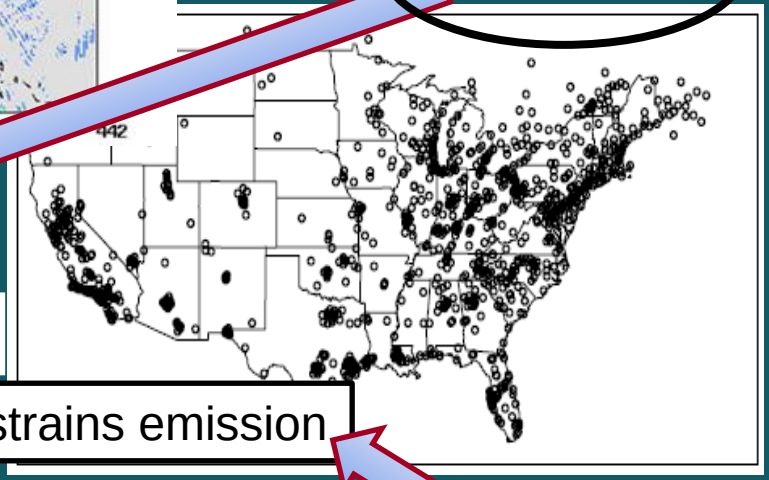


AOD





AIRNow



Constrain Chemical fields

Constrains Cloud-obs Photolysis rates

Constrains emission

Biogenic emissions

GOES-MCIP INTERFACE

Cloud transmissivity (calculated from satellite retrieved cloud albedo), cloud top pressure, and cloud fraction are prepared for input to MCIP

MODIFIED MCIP

GOES retrievals replaces MM5 cloud information being passed to CMAQ. Cloud fraction, transmissivity, cloud base and top heights are passed to CMAQ.

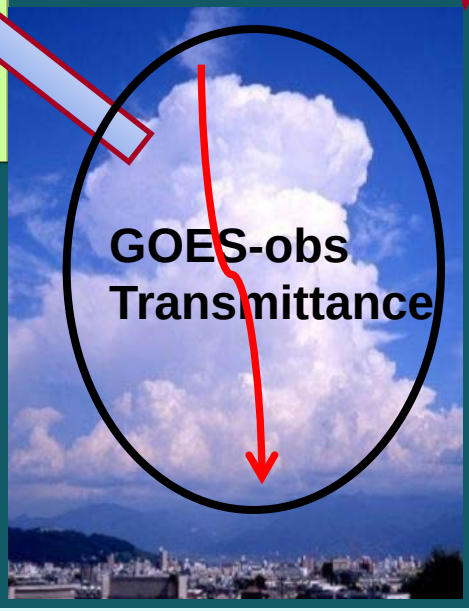
PHOT in CMAQ

In subroutine PHOT, clear sky photolysis rates will be adjusted for cloud cover based on GOES cloud fraction and cloud transmissivity information.

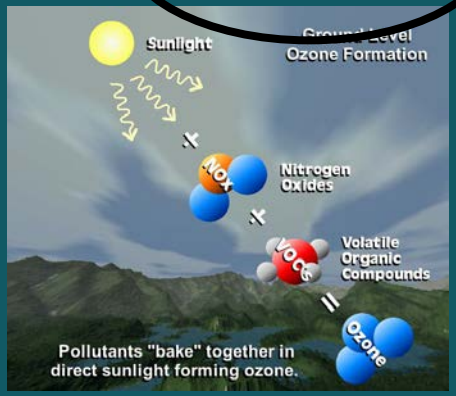
Interpolated in between.

Cloud Base According to Lifting Condensation Level

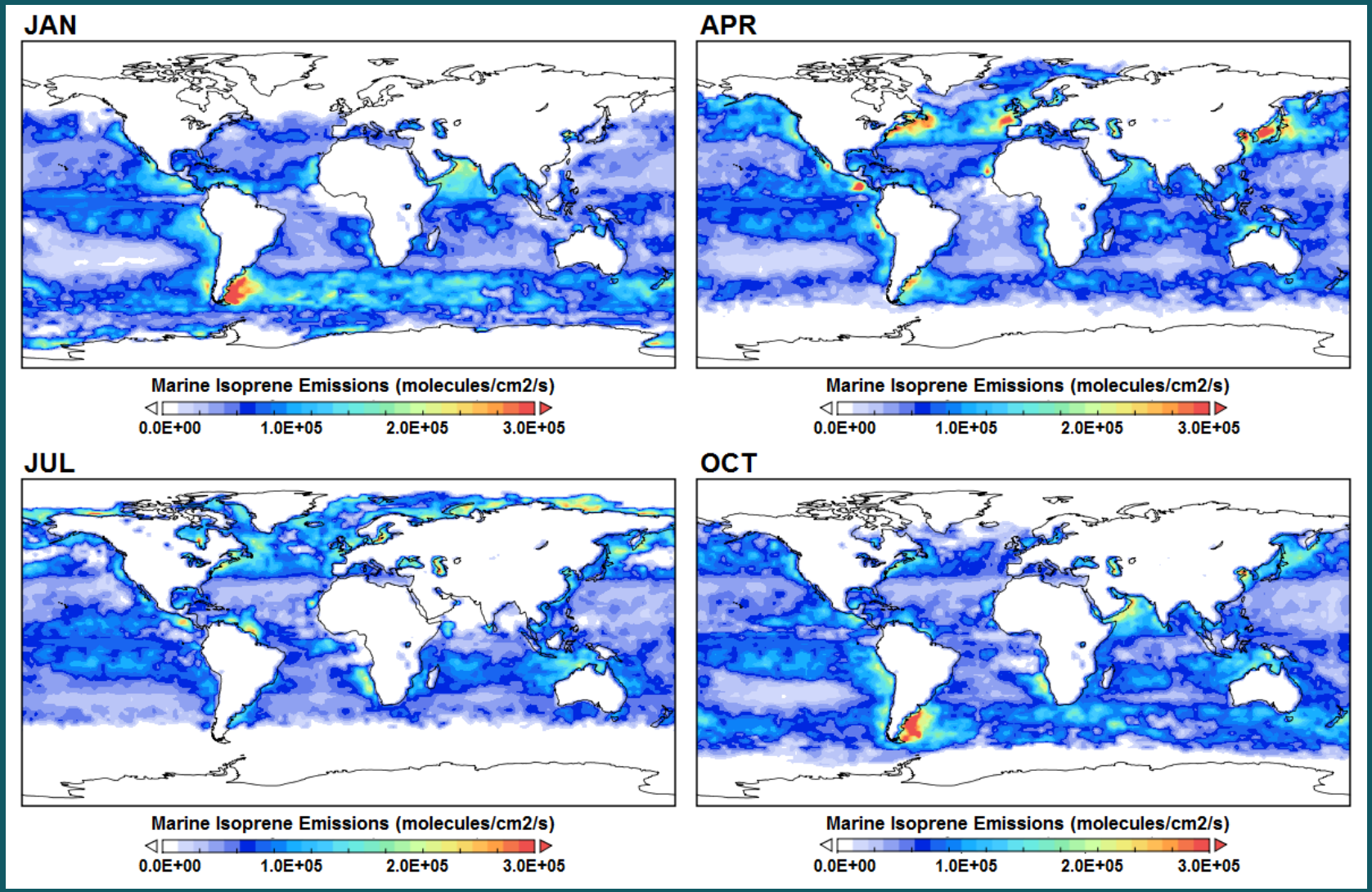
$$T_c = B \Big/ \ln\left[\frac{A\varepsilon}{wp_0}\left(\frac{T_0}{T_c}\right)^{3.5}\right]$$

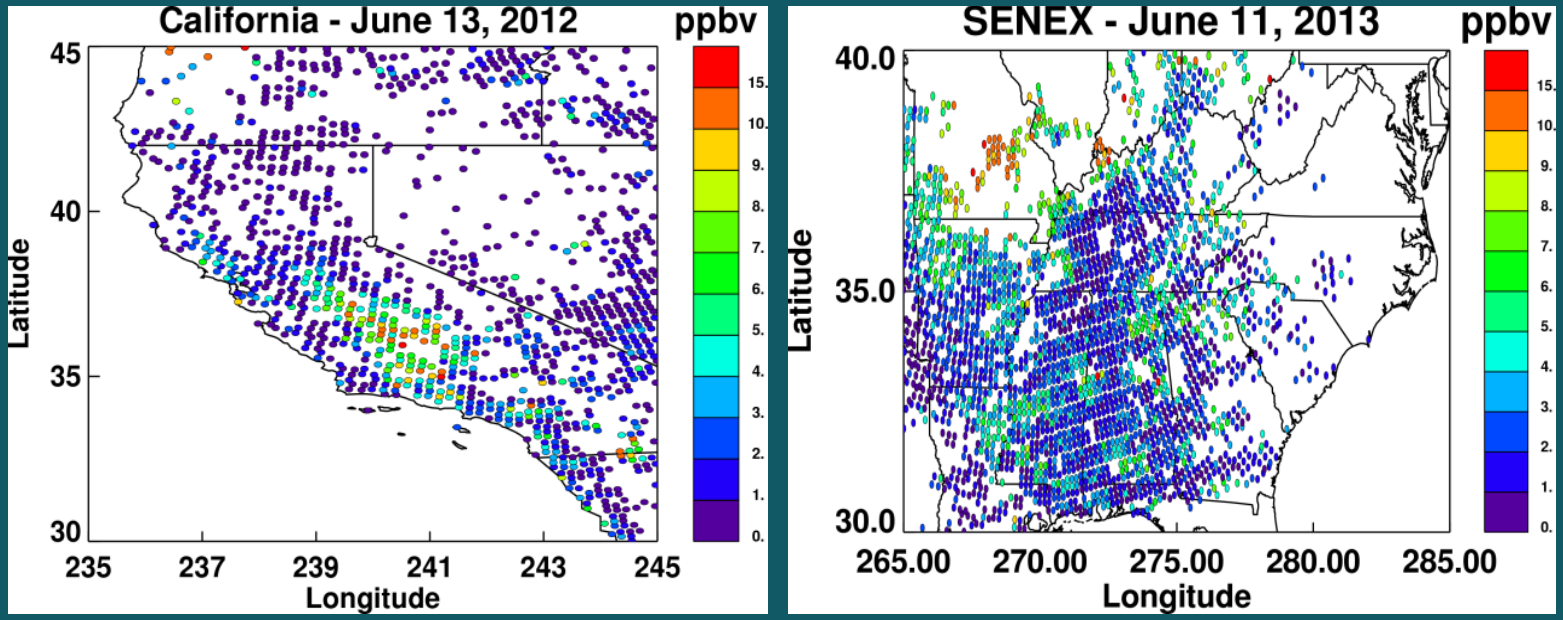


GOES-obs Transmittance



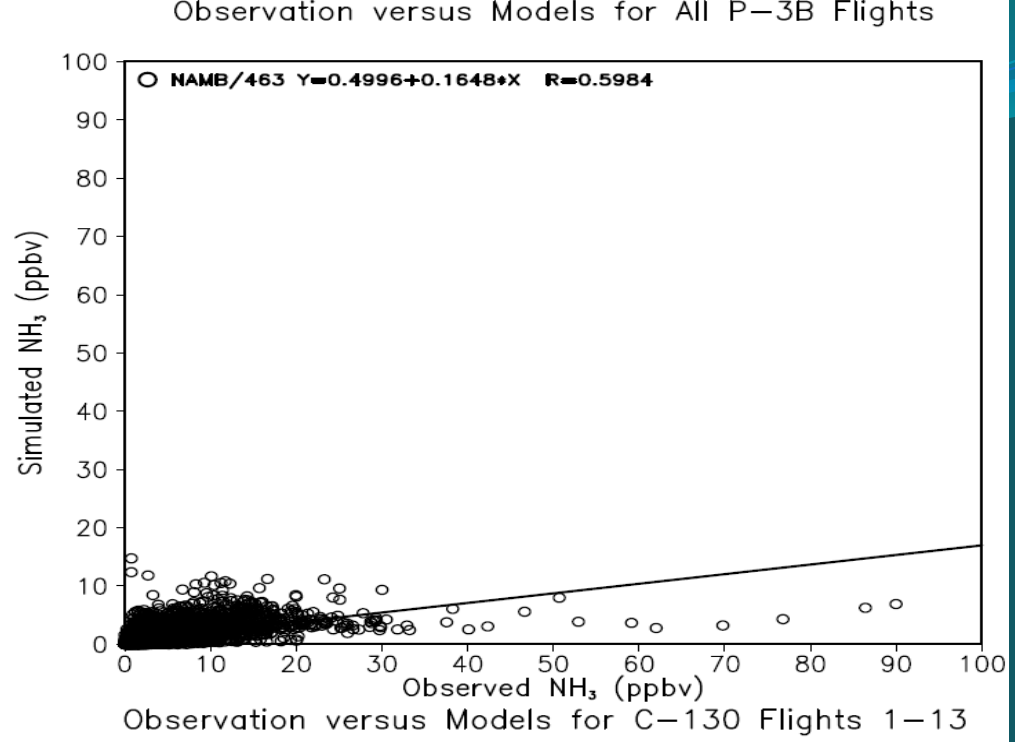
Global Distribution of Marine Isoprene

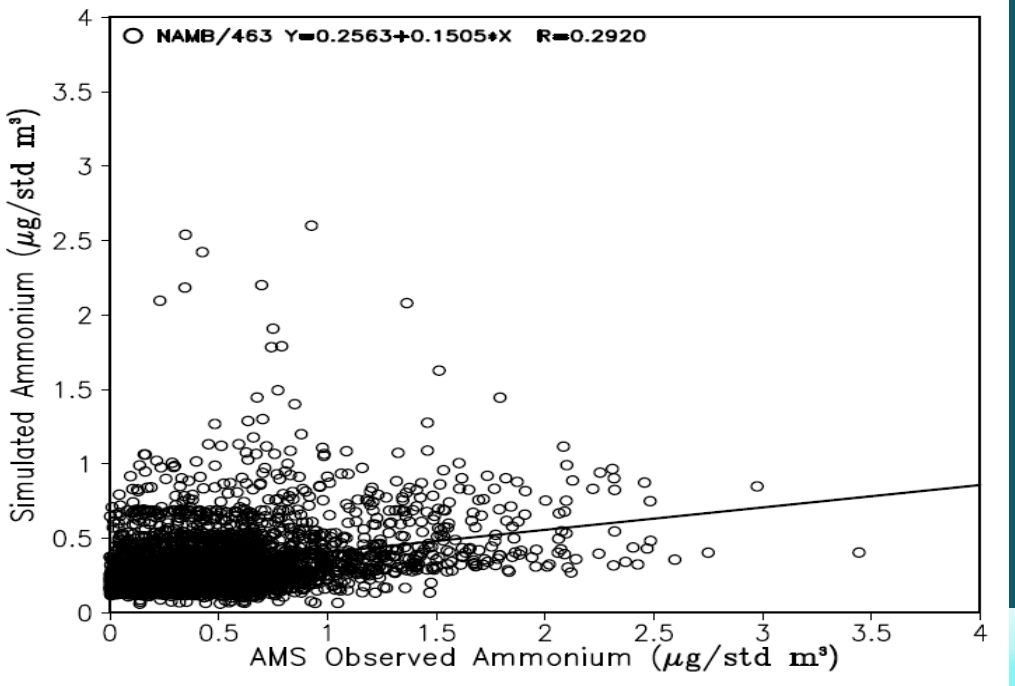




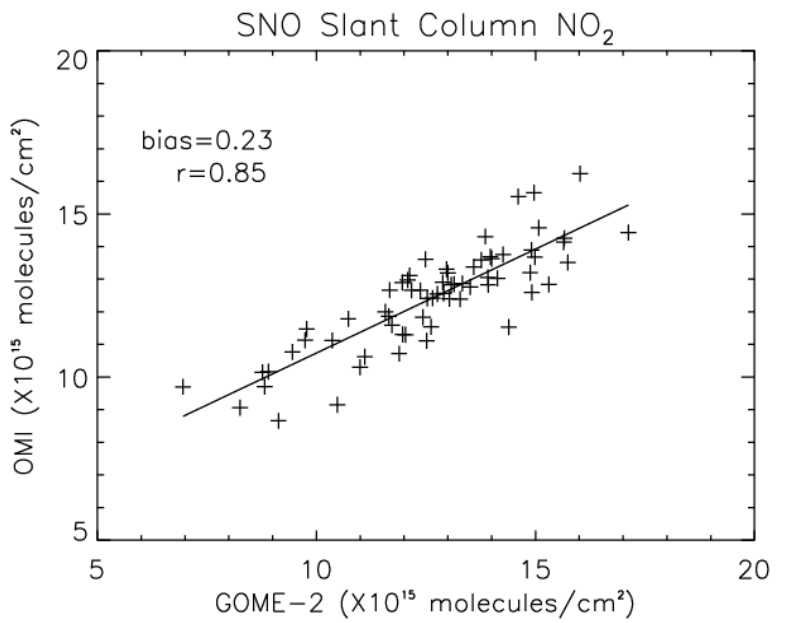
(left) CrIS NH_3 retrieval results over California plotted using the NH_3 representative volume mixing ratio (RVMR), which is approximately the retrieved value at the height of peak sensitivity of CrIS to NH_3. Most missing data is due to the presence of clouds. (right) The same but for the Southeast US during the NOAA SENEX campaign.

We systematically underestimated ammonia concentrations as well as ammonium.

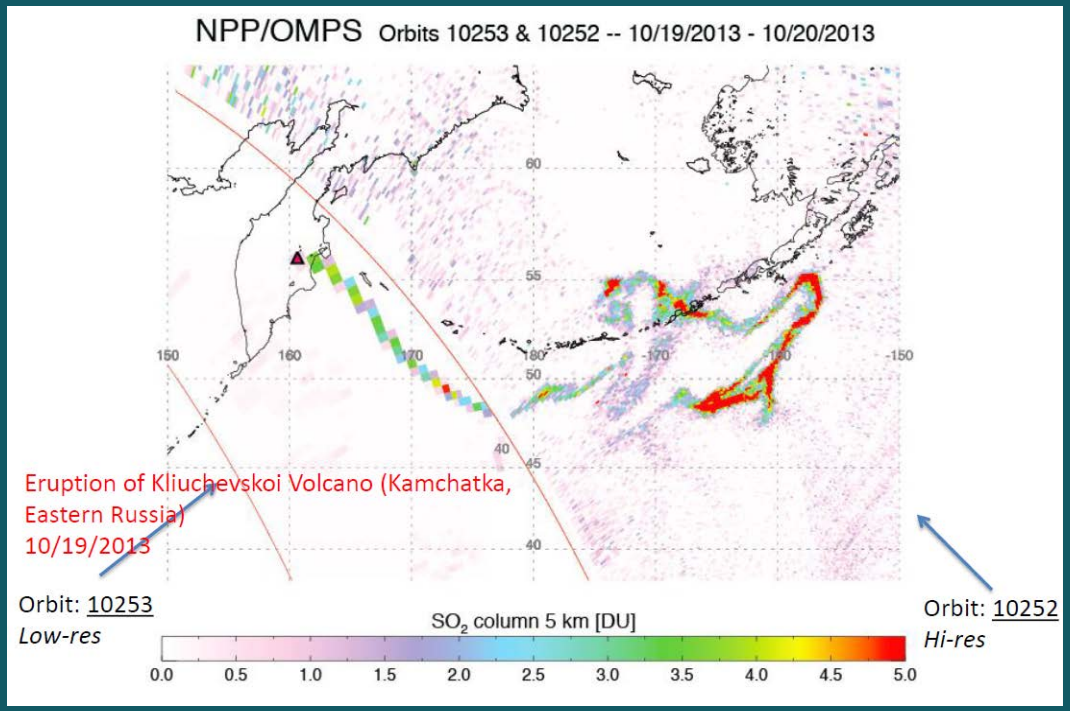








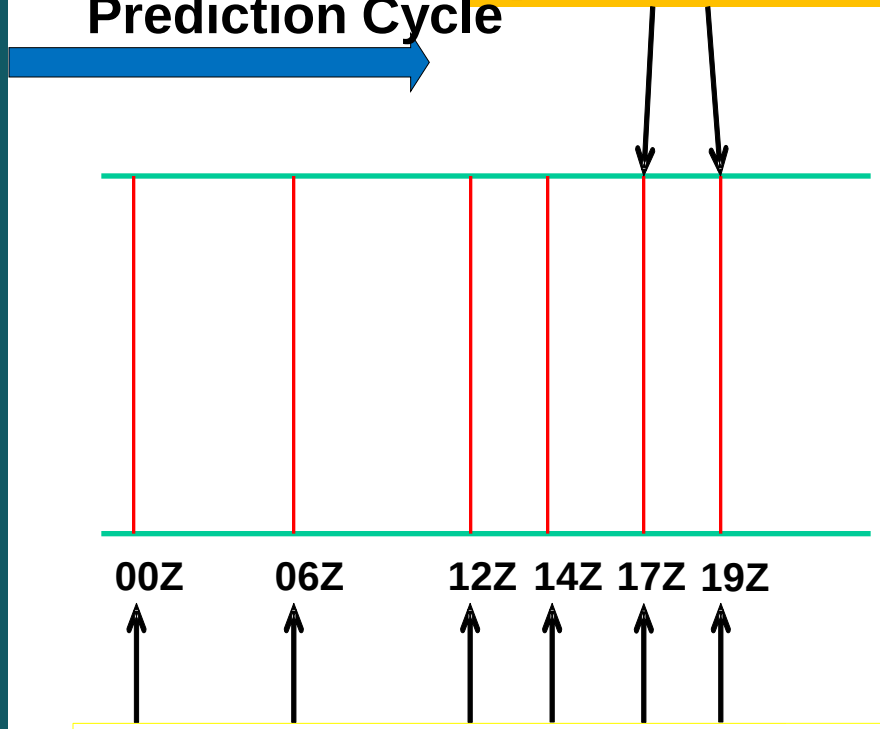
Simultaneous nadir overpass analysis comparisons of GOME-2 and OMI. The top left figure shows an example overpass of two satellites. We restricted data to less than 80° solar zenith angle, nadir only. Results are shown in the scatter plot on the right with GOME-2 on x-axis and OMI on y-axis. Both agree well with a correlation coefficient of 0.85 and a mean bias of about 2%. This agreement gives us confidence that we can now use OMI and GOME-2 tropospheric retrievals to study the diurnal variations at other latitudes.



SO_2 products from processing by K. Yang, NASA OMPS Science Team Member. The data for the low-resolution orbit has 35 cross-track FOVs 50x50 KM^2 at nadir. The high-resolution orbit has 175 cross track FOVs 10x10 KM^2 at nadir. Lower resolution data will be obtained starting with OMPS on JPSS01. The data shows the volcanic SO_2 plume from Kliuchecevskoi (located at the red triangle) as observed by S-NPP OMPS for October 19-20 2013.

CMAQ: cb05_ae4
2008 anthropogenic emission inventory projected to 2015
NOAA HMS (hazard mapping system) fire emission with Bluesky algorithm

VIIRS/MODIS AOD (Terra and Aqua)

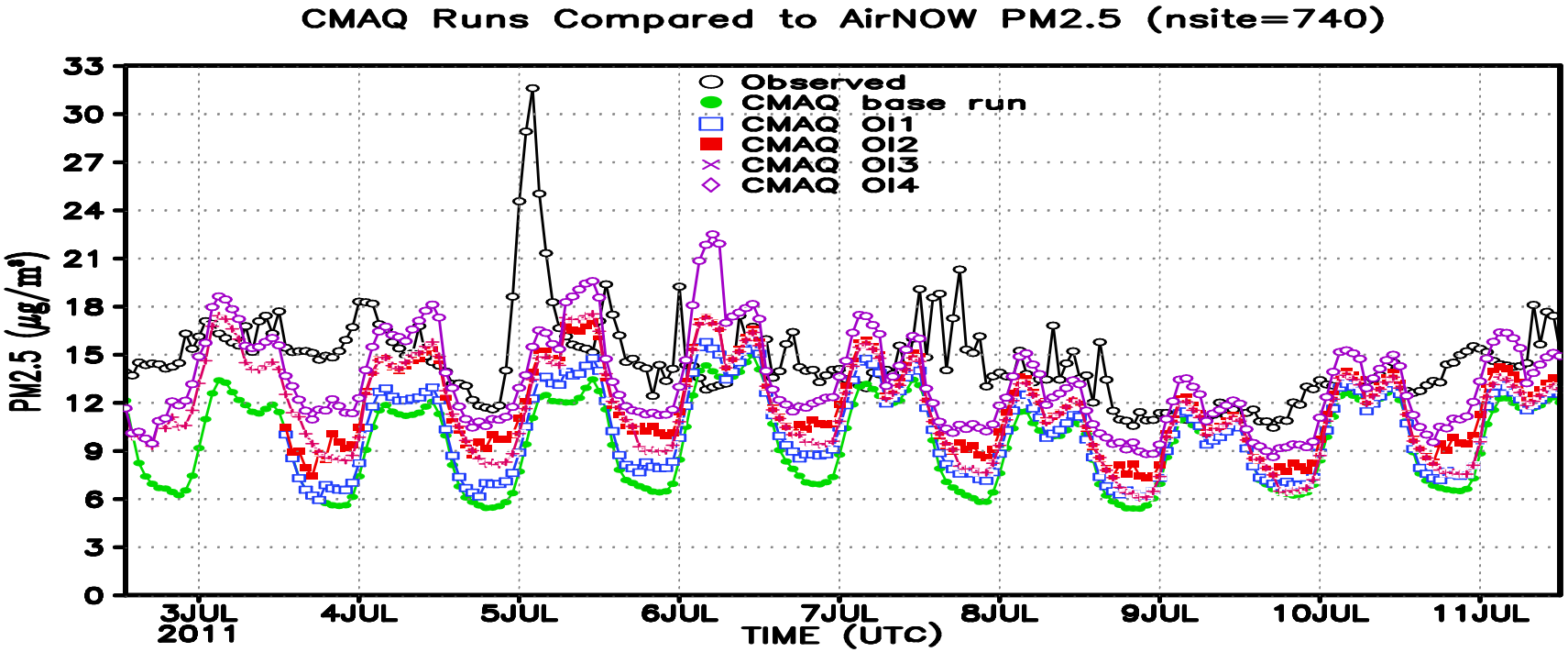


AIRNow $PM_{2.5}$, PM_{10}, Ozon (applied to below PBL)

Cases of Studies	Assimilation Times	Settings of U Settings of Uncertainties
OI1 (7×7 OI)	00z, 06Z, 12Z, 18Z for AIRNow data 18Z for MODIS AOD (+/- one hour)	0.6 for modeled aerosols and 0.4 for modeled O_3.
OI2 (7×7 OI)	00Z, 06Z, 12Z, 14Z, 17Z, 19Z for AIRNow 17Z and 19Z for MODIS (+/- two hours)	2.0 for modeled aerosols and 0.4 for modeled O_3.
OI3 (7×7 OI)	00Z, 06Z, 12Z, 14Z for AIRNow 17Z and 19Z for MODIS (+/- two hours)	Dynamic uncertainties up to 5.0 for modeled PM2.5, and up to 0.6 for modeled O_3.
OI4 (11×11 OI)	00Z, 06Z, 12Z, 14Z, 17Z, 19Z for AIRNow 17Z and 19Z for MODIS (+/- two hours)	Dynamic uncertainties up to 10.0 for modeled PM2.5, and up to 1.0 for modeled O_3.

Hourly Statistic Results for CONUS 12Z, 07/06/2011- 12Z, 07/07/2011

Cases	O_3	PM2.5
Base case	R=0.53 MB=2.54	R=0.23 MB= -7.14
OI1	R=0.56 MB=2.36	R=0.24 MB= -2.63
OI2	R=0.58 MB=1.06	R=0.39 MB= -1.33
OI3	R=0.52 MB=2.08	R=0.36 MB= -1.89
OI4	R=0.56 MB=1.55	R=0.40 MB= -0.11



	Aqua-MODIS	Suomi NPP-VIIRS
Orbit altitude	705 km	824 km
Equator crossing time	13:30 LT	13:30 LT
Granule size	5 minutes	86 seconds
Swath	2330 km	3040 km
Sensor zenith angle range	±64°	±70°
Valid solar zenith angle (for high quality)	< 82°	≤ 65°
Sensor bands used for aerosol retrieval	0.412, 0.466, 0.554, 0.646, 0.856, 1.24, 1.63, 2.11 μm	0.412, 0.445, 0.488, 0.555, 0.672, 0.746, 0.865, 1.24, 1.61, 2.25 μm
Pixel size, nadir	0.25, 0.5, and 1 km	0.375 and 0.75 km
Bow-tie effects	Yes	No
Product resolution, nadir	10 km	6 km (AOT and Angstrom exponent) 0.75 km (Suspended matter)
Product resolution, edge	40 km	10 km (AOT and Angstrom exponent) 1.2 km (Suspended matter)
Products, land (vegetated regions)	AOT (Dark Target Approach)	AOT, Angstrom exponent, Suspended matter
Product, land (deserts, urban regions)	AOT, Angstrom exponent, Dust single scattering albedo (Deep Blue Approach)	None
Products, ocean	AOT (7 wavelengths), Size (fine mode fraction)	AOT (11 wavelengths), Angstrom exponent, Suspended matter
Global gridded product	Level 3 daily, 8-day, monthly mean	None

Courtesy: C. Hsu et al.

Summary

- **NH3**
- ***SO2***
- ***Constraints for emission projection, photolytic rates, initialization adjustment of chemical fields***
- ***VIIRS should give NAQFC further advantages due to finer temporal and spatial resolution of the retrieved data***

EXTRA SLIDES

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Next data set
To be include
In data assimilation?

MLS & MODIS
AOD from global
Model: e.g., RAQMS

Exo-domain as well
as endo-domain
wild fires &
prescribed
burns

