ARL

Air Resources Laboratory

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

Partnership in Air Quality Forecasting ---

Local agency forecasters, managers and NOAA

Pius Lee – NOAA Air Resources Lab (ARL)

with contributions from:

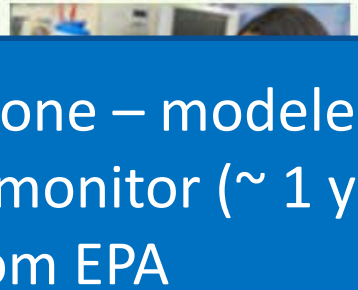
NOAA ARL: Daniel Tong, Li Pan, Youhua Tang, Barry Baker
NOAA National Centers for Environmental Prediction: Jeff McQueen, Jianping Huang, Ho-Chun Huang
NOAA National Weather Service: Ivanka Stajner, Sikchya Upadhayay
U.S. EPA: John White, Brad Johns
N.Y. State University, Albany: Sarah Lu, Shengpo Chen

CDC emphasis

Environments

- Climate Change
- Outdoor Air NEW
- Water
- More

Health Effects



- Asthma

Population Health

- Population Character
- Health Impact Asses NEW
- Children's Environme Health
- More

1. Ozone – modeled (~ 3 yr data lag) & monitor (~ 1 yr data lag), both from EPA
2. PM2.5 mass - modeled (~ 3 yr data lag) & monitor (~ 1 yr data lag), both from EPA
3. Air Toxics - benzene, formaldehyde, modeled from EPA, 2005 only (NATA)

NAQFC can provide $PM_{2.5}$ speciation data with national coverage at county level, which are highly valuable for health effects studies

Thank you for voicing support to NAQFC

"I am writing to comment on the *Proposed Termination of NWS Ozone Air Quality Predictions* …

The NAQFC is the only numerical forecast model that is available every day, is fully documented, accessible for evaluation, and shows good forecast skill. It should be retained". (November 1 2012, Bill Ryan, PSU)

On "The proposal to shelve the $5.4 million National Air Quality Forecasting Capability in March has drawn protests from public health officials…" (January 26 2013, Dan Vergano, USA Today)

O	Comments opposing termination of predictions
	State and local agencies, air quality forecasters and regional consortia involved in air quality forecasting

O1

MDE

MARYLAND DEPARTMENT OF THE ENVIRONMENT

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410-537-3000 • 1-800-633-6101 • www.mde.state.md.us

Martin O'Malley
Governor

Anthony G. Brown
Lieutenant Governor

Robert M. Summers, Ph.D.
Secretary

Comments of the Maryland Department of the Environment on the Proposed Termination of NWS Air Quality Predictions

The Maryland Department of the Environment (MDE) hereby submits these comments on the proposal of the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) to terminate the National Air Quality Forecast Capability (NAQFC) ozone and fine particle pollution ($PM_{2.5}$) models. Maryland urges NWS to reconsider its proposed termination of the NAQFC models. Since 2004, NAQFC has worked toward developing and improving its air quality models to support the air quality scientific community. MDE provides the official air quality forecasts for ground-level ozone and $PM_{2.5}$ for Maryland residents. In doing so, MDE meteorologists frequently utilize NAQFC model guidance as an important resource when preparing the State's official air quality forecasts.

November 2012, MDE as O1

Partnering with AQ Forecasters

Focus group, State/local AQ forecasters:

- Participate in real-time developmental testing of new capabilities, e.g. aerosol predictions
- Provide feedback on reliability, utility of test products
- Local episodes/case studies emphasis
- Regular meetings; working together with EPA's AIRNow and NOAA
- Feedback is essential for refining/improving coordination

Examples of AQ forecaster feedback (Jan 2016) :

➢ O3

ME: NOAA model within 5 ppb of the obs --fairly good

CT: NOAA model out-performs human forecast (73% vs 54%) since 2012 summer time hig-bias reduced

MD: NOAA model showed significant improvement in reduction in False Alarm rate since 2011.

NC: Bias and accuracy statistics for NAQFC ozone predictions improved

CA: Often under prediction in the Foothill regions ion L.A. Fine resolution modlelng is probably a requirement.

➢ PM2.5

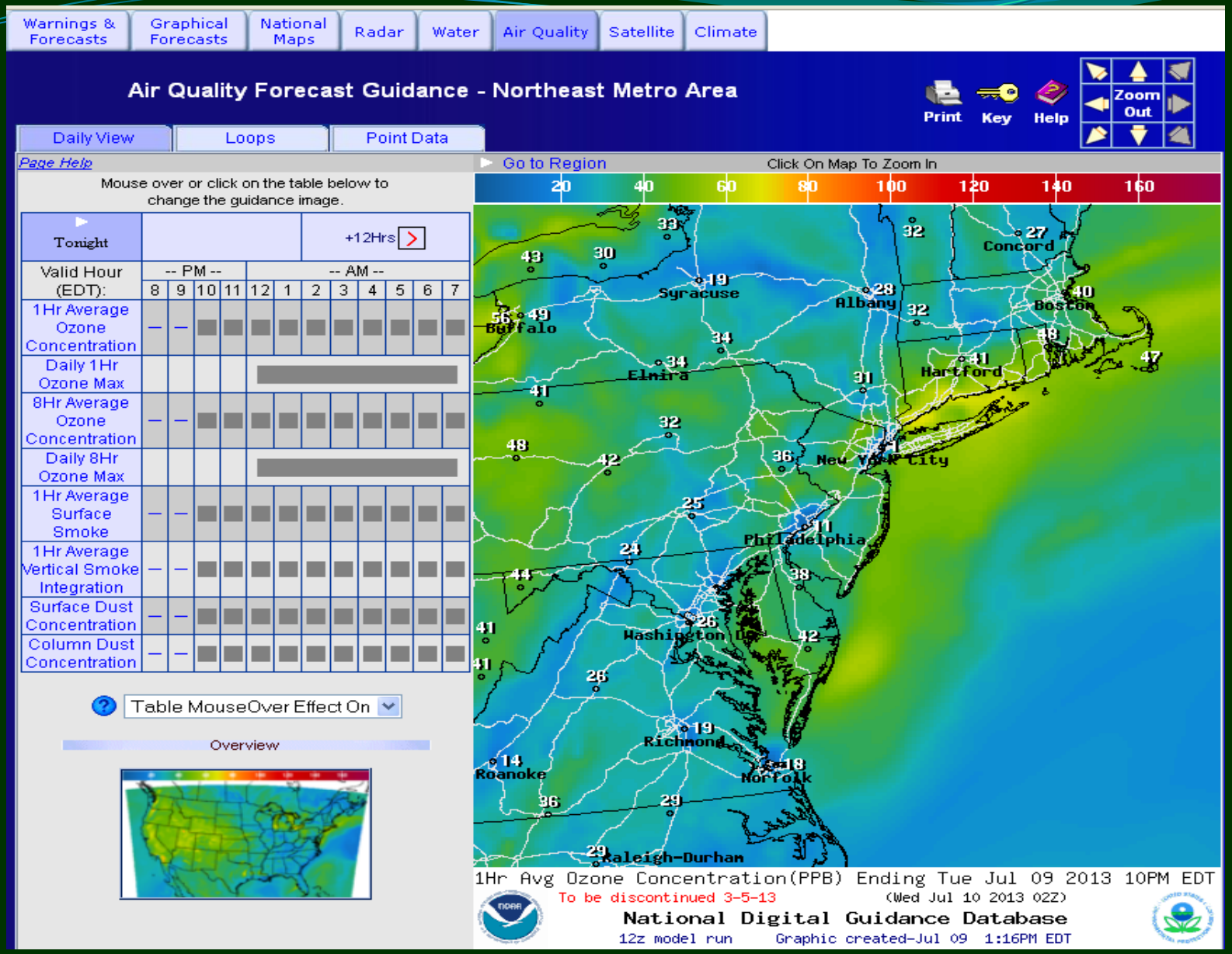
TX: NOAA model are useful for giving context to our daily forecast: Model does well identifying localtion of highest Pm2.5 from local/continental sources. It typically over predicts . Model seemed to achieve reduction of such high-bias gradually in recent years.

WA: We use NOAA model when our local model products fail or are providing ambiguous guidance.

SC: The PM2.5 forecast can potentially be disseminated within oyr own state

http://airquality.weather.gov*

URL1



*National Digital Guidance Database

http://www.emc.ncep.noaa.gov/mmb/aq*

Air Quality Forecast (AQF)
Public Page
Focus Group Feedback
AQF Verification Page
Documents

Change Type:
Daily sfc max or avg

Year: 2013 Month: Jul Day: 08

Select Cycle:
06Z

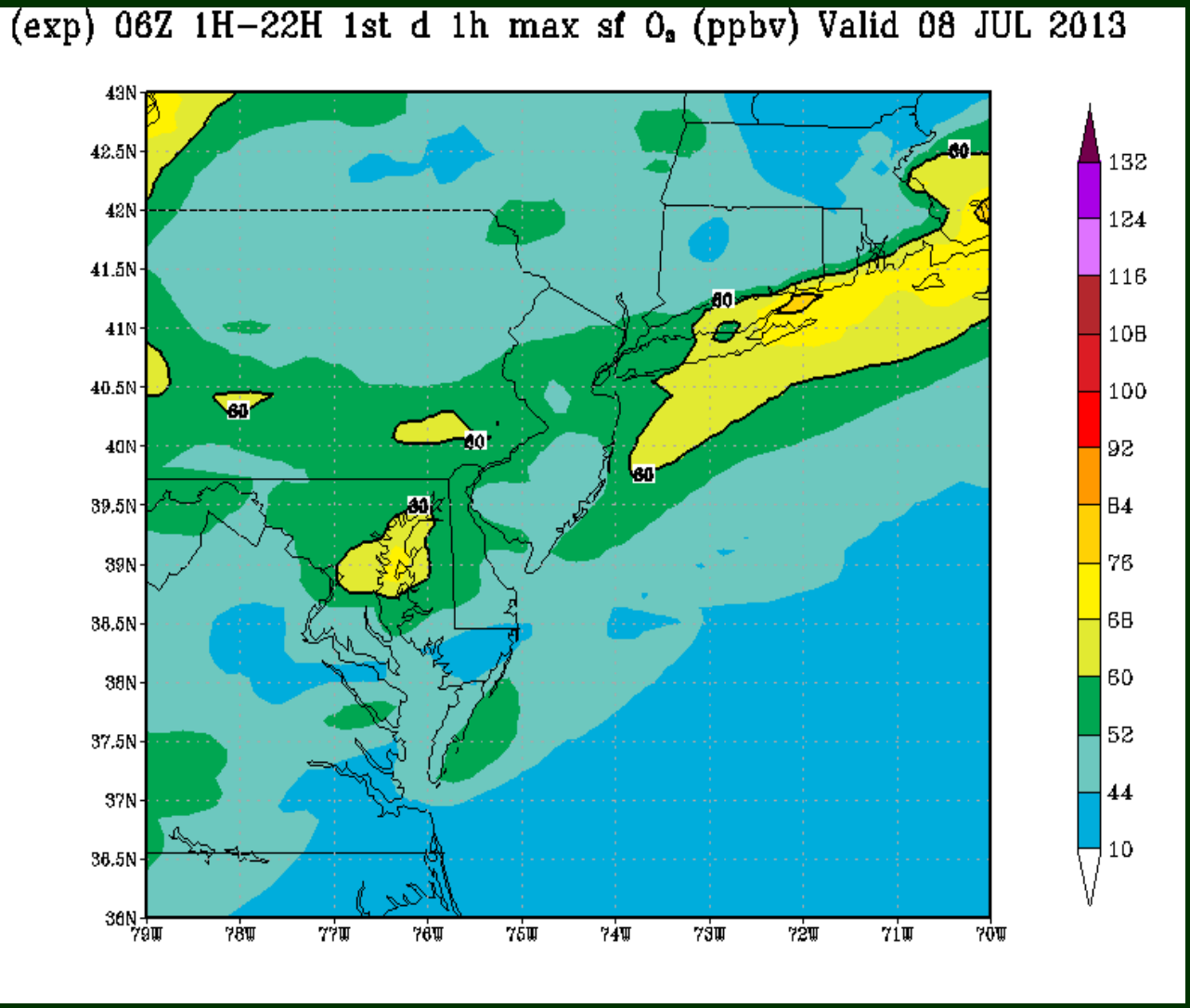
Select Field:
target(4Z-4Z) day_1 O3 1h max

Select Region:
Along I95 Corridor

Get map

NCEP Home
NOAA Home
EPA Home

Send Comments



*National Centers for Environmental Prediction

http://testbed.arl.noaa.gov/AQ_forecast.php*

Enter search term(s) Go

ARL site only All of NOAA

- ARL Home
- 2011 Lab Review
- HYSPLIT Model
- READY
- Air Quality
- Atmospheric Dispersion
- Climate
- Boundary Layer

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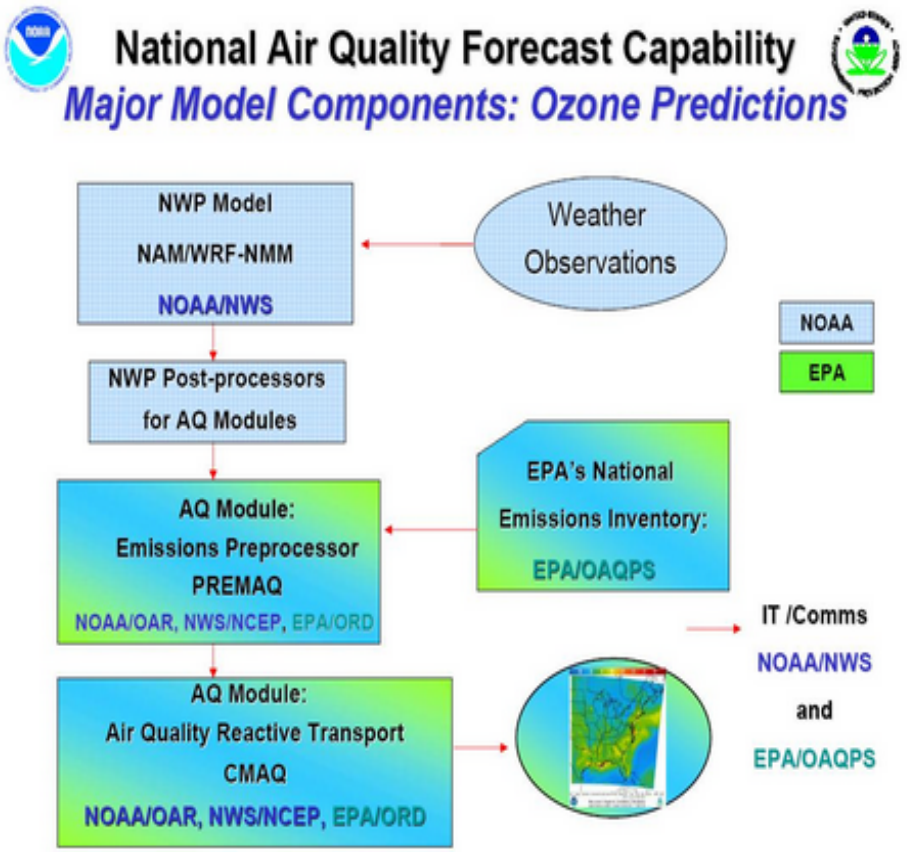
Air Quality Forecasts

Operational Air Quality Forecasts

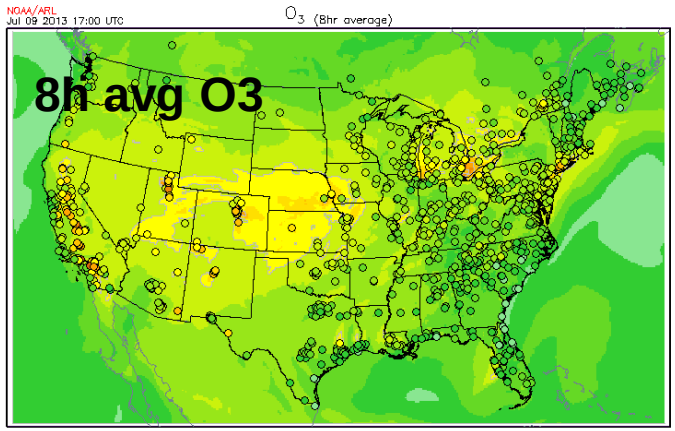
Currently, National Air Quality Forecast System provides ozone, particulate matter and other pollutant forecasts over the continental US with 12 kilometer resolution. The air quality forecast guidance through midnight next day help to prevent or reduce adverse effects.

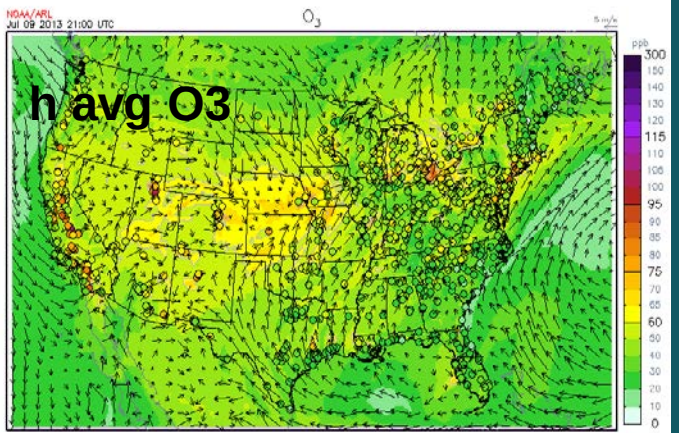
- Ozone and PM Spatial Plots
- CMAQ4.7.1 Ozone and PM Spatial Plots
- Surface weather charts, satellite and radar composites, Radar images from NOAA/NCDC, UCAR image archive
- Meteorogical Input Spatial Plots
- NAMB Meteorogical Input Spatial Plots
- Emission Spatial Plots



*Air Resource Laboratory, NOAA

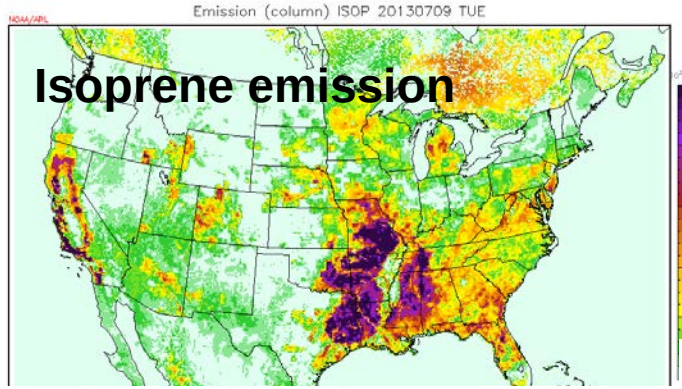
http://testbed.arl.noaa.gov/AQ_forecast.php: Sample fields, plots

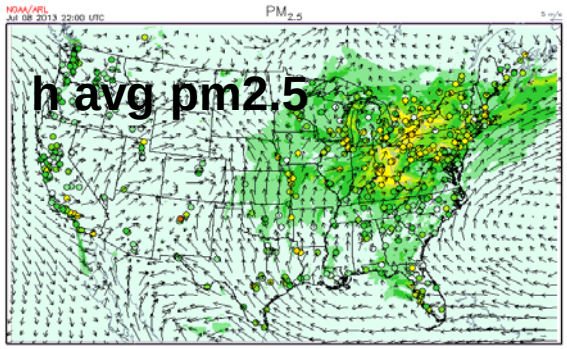


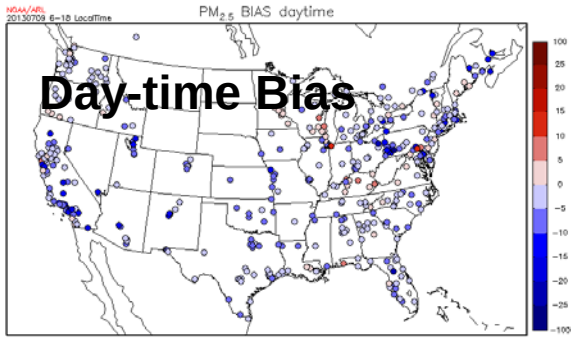


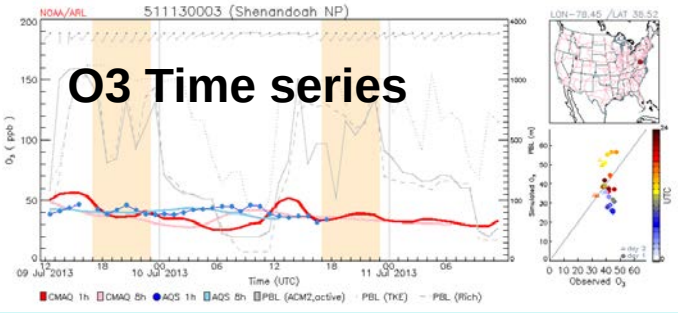
NAM AIR QUALITY DIAGNOSTIC DISCUSSION

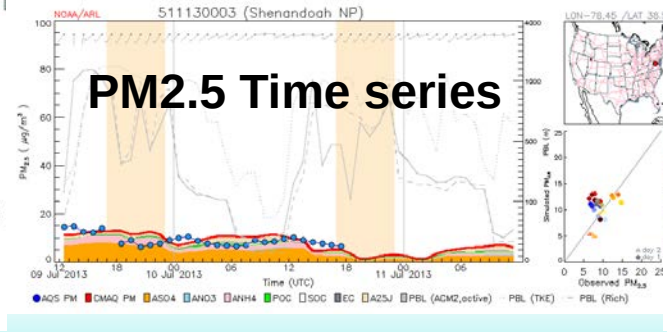
http://www.hpc.ncep.noaa.gov/discussions/aqm.html

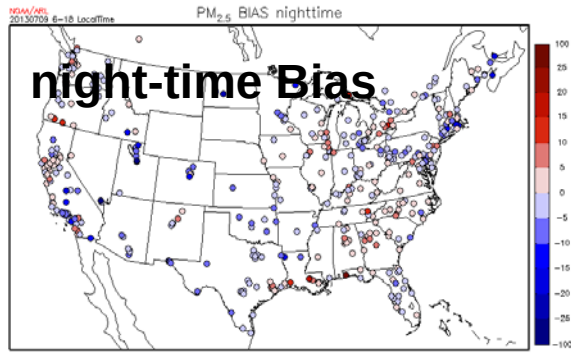






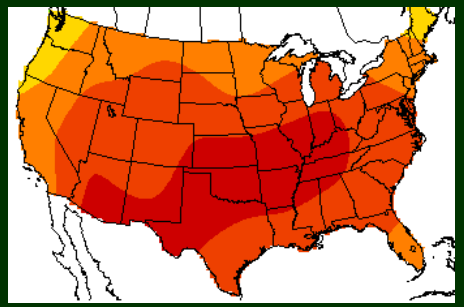




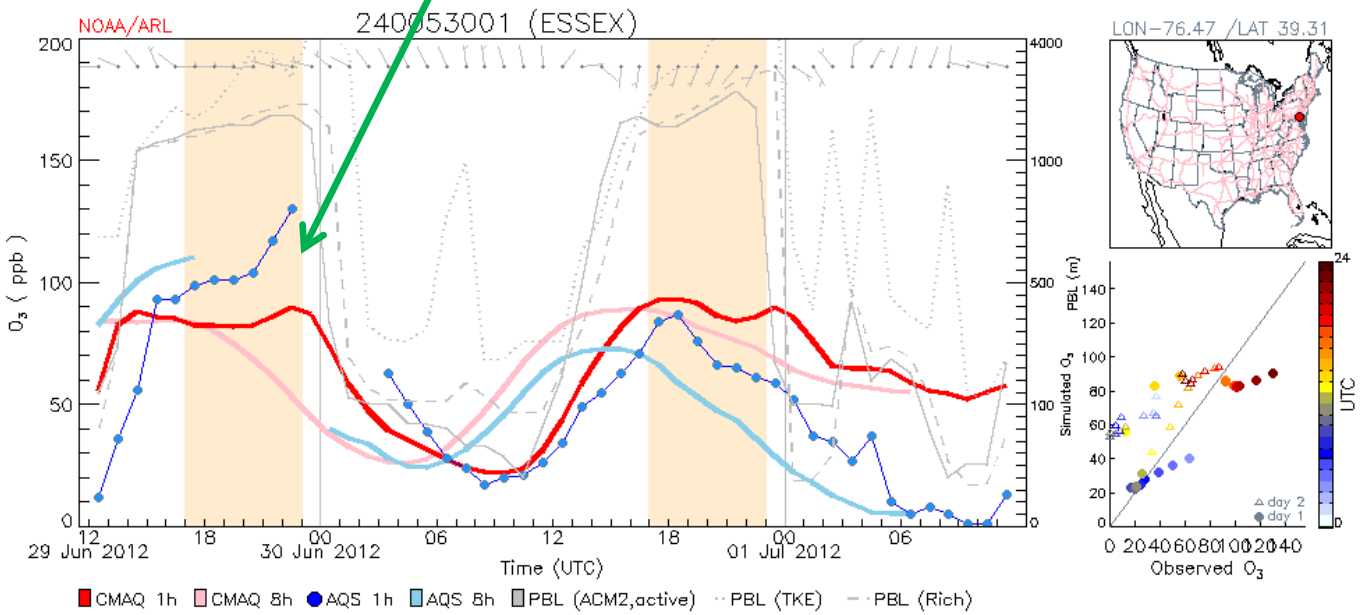


- In 2012, 29 Maryland ozone exceedance days of the 75 ppb 8-hour National Ambient Air Quality Standard
- June 29, 2012, Maryland's worst day of the season
  - All 18 MDE monitors ≥ 85 ppb for 8-hour average
  - Highest 8-hour average was 113 ppb at Horn Point monitor on the Eastern Shore
  - Highest 1-hour average was 130 ppb at Essex in the Baltimore Metro region

Courtesy: Laura Warren (MDE)



Heat wave?



Governing Equation and Inputs prescribe NAQFC Results

$$\frac{\partial(\overline{\varphi}_i J_\xi)}{\partial t} + m^2 \nabla_\xi \bullet \left(\frac{\overline{\varphi}_i \hat{\overline{\mathbf{V}}}_\xi J_\xi}{m^2} \right) + \frac{\partial(\overline{\varphi}_i \hat{\overline{v}}^3 J_\xi)}{\partial \hat{x}^3}$$

$$+ m^2 \frac{\partial}{\partial \hat{x}^1}\left[\frac{\overline{\rho} J_\xi}{m^2}\hat{F}^1_{q_i}\right] + m^2 \frac{\partial}{\partial \hat{x}^2}\left[\frac{\overline{\rho} J_\xi}{m^2}\hat{F}^2_{q_i}\right] + \frac{\partial}{\partial \hat{x}^3}\left[\overline{\rho} J_\xi \hat{F}^3_{q_i}\right]$$

$$= J_\xi R_{\varphi_i}(\overline{\varphi}_1, \ldots, \overline{\varphi}_N) + J_\xi Q_{\varphi_i} + \left.\frac{\partial(\overline{\varphi}_i J_\xi)}{\partial t}\right|_{cld} + \left.\frac{\partial(\overline{\varphi}_i J_\xi)}{\partial t}\right|_{aero} + \left.\frac{\partial(\overline{\varphi}_i J_\xi)}{\partial t}\right|_{ping}$$

Quality of forecasting depends on both model formulations and inputs.

For NAQFC, daily meteorology is the main driver but IC, BC, and emissions can affect forecasting quality as well.

Demonstrate how NAQFC can be affected by wind & cloud (photolysis), emissions, and IC

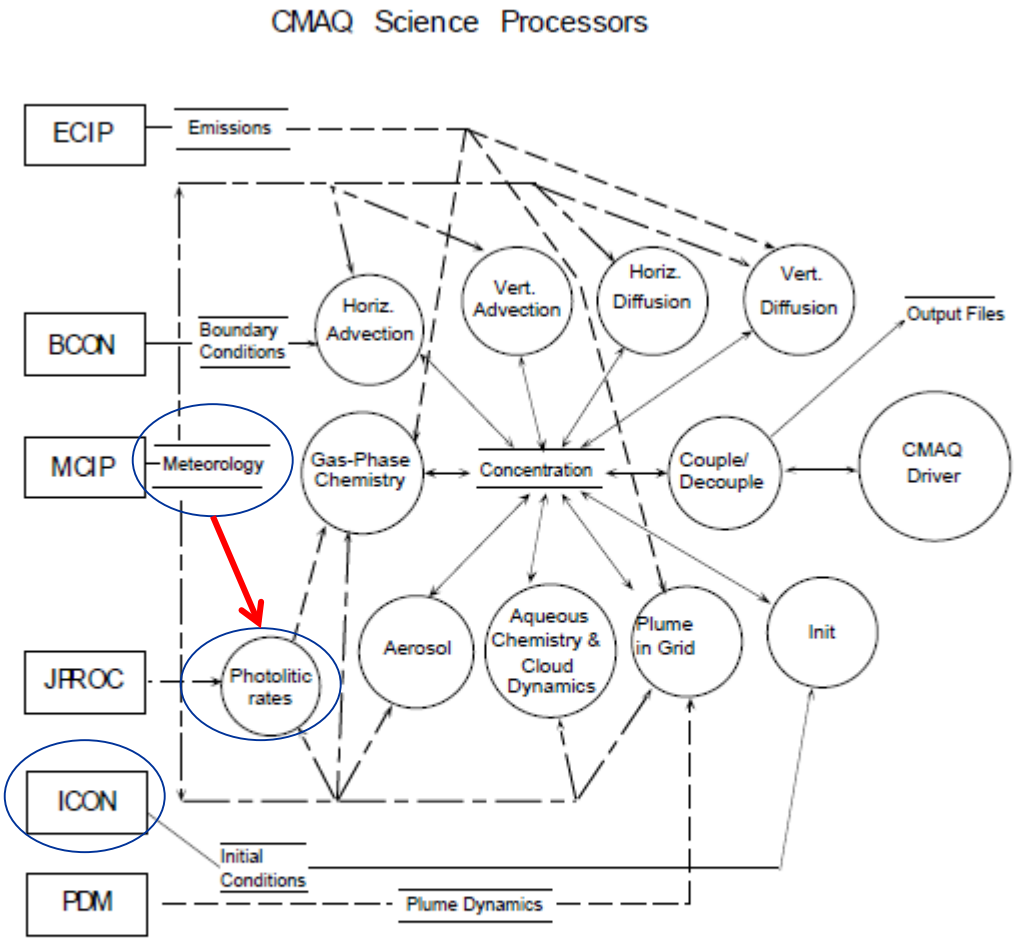


Figure 6-1. Science Process Modules in CMAQ. Interface processes are shown with rectangular boxes. Typical science process modules are updating the concentration field directly and the data-provider modules include routines to feed appropriate environmental input data to the science process modules. Driver module orchestrates the synchronization of numerical integration across the science processes. Concentrations are linked with solid lines and other environmental data with broken lines. (From Byun et al., 1998.)

https://www.cmascenter.org

Download CMAQ to your linux machine

Three tar-balls:

- **TOOLS**
- **DATA_REF**
- **CMAQv5.1**

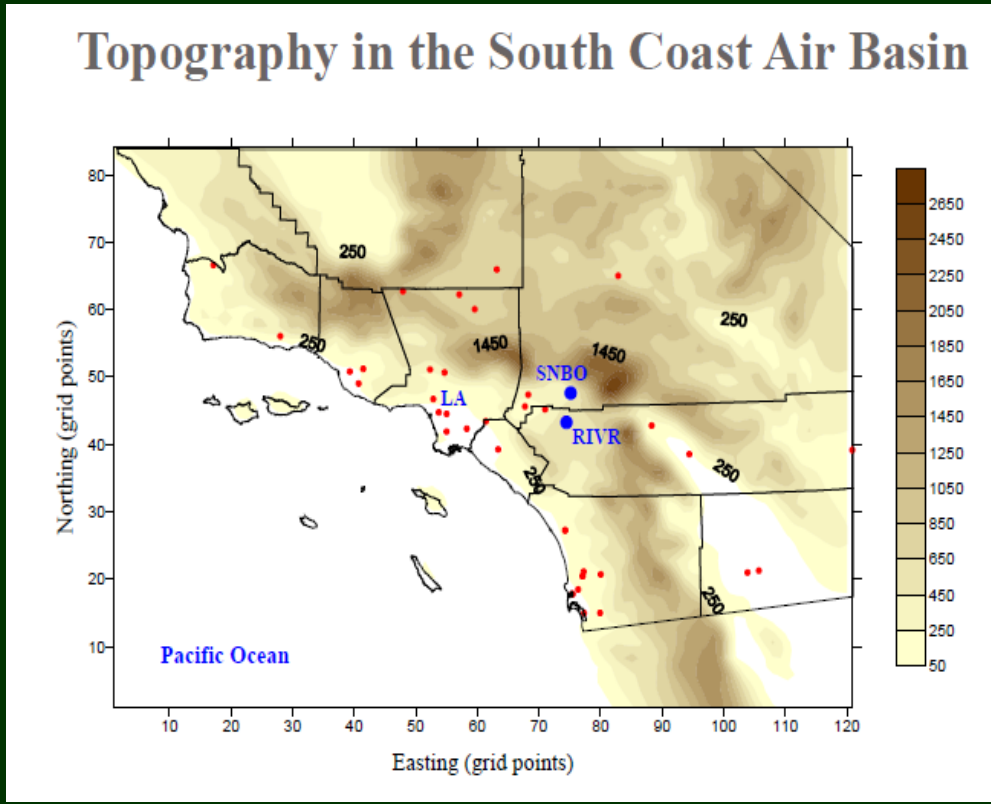
Under CMAQv5.1 : data (CalNex domain) models scripts

Under CMAQv5.1/scripts/cctm/bldit.cctm: Option Selection

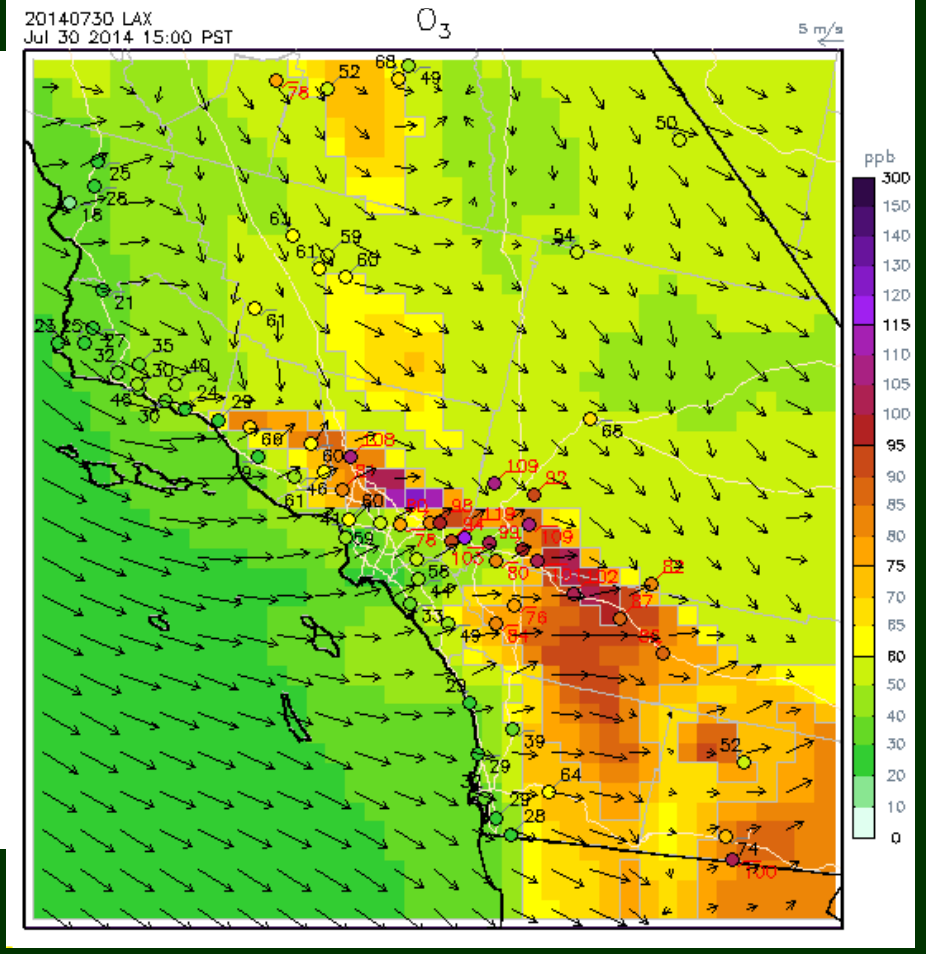
Choose physical, chemical and numerical schemes

MECHS Module	Aerosol Module	Cloud Module
cb05e51_ae6_aq	aero6	acm_ae6
saprc07tb_ae6_aq	aero6	acm_ae6

Higher spatial and chemical regime resolution

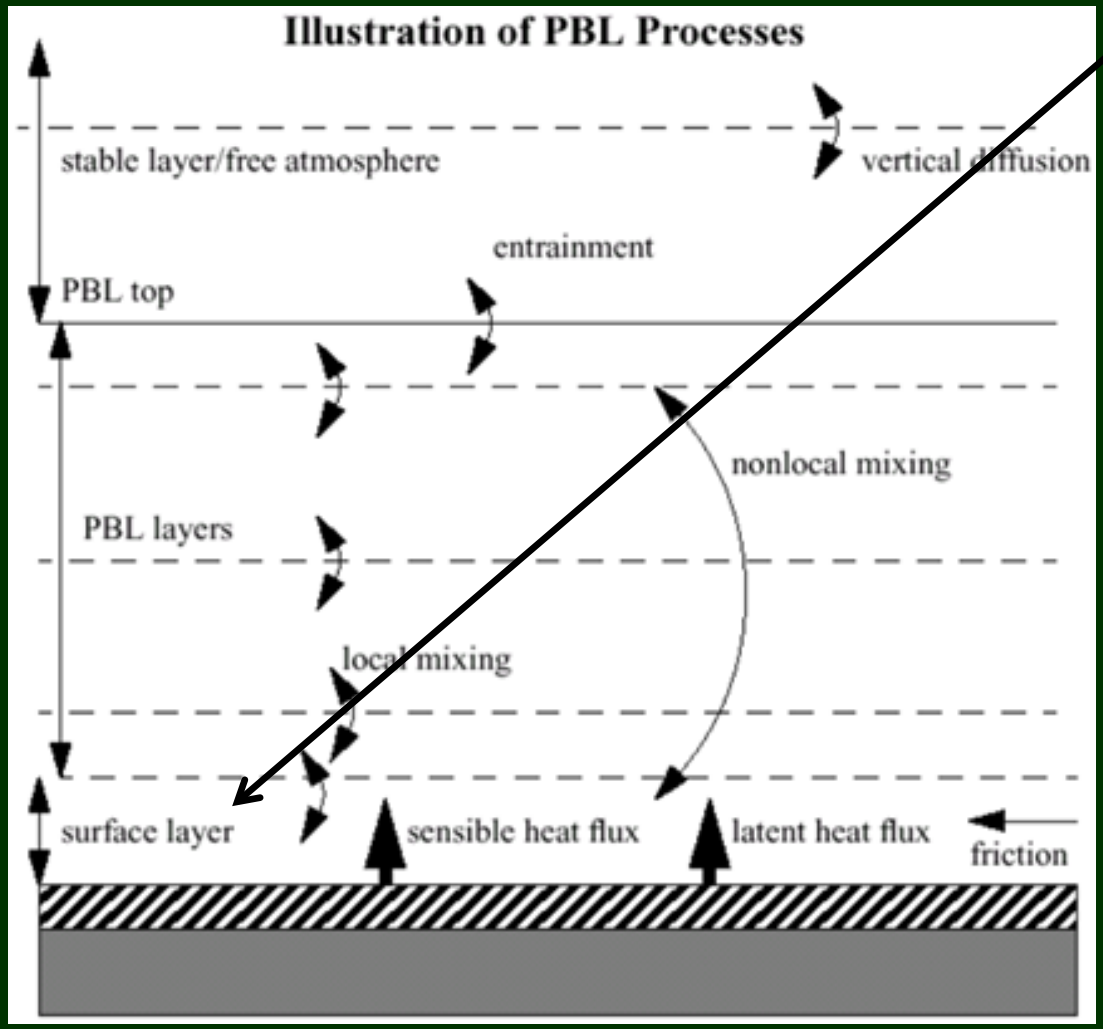


NAQFC sfc O3 for a typical summer



Courtesy: Sang-Mi Lee
South Coast AQ Management District

Investigate surface layer similarity scheme



Rather large values of vertical eddy diffusivity in the lower portion of PBL that resulted in too strong mixing below 250 m.

$$\phi_m = \left(1 + 5\frac{0.1h}{L}\right)$$

for stable condition

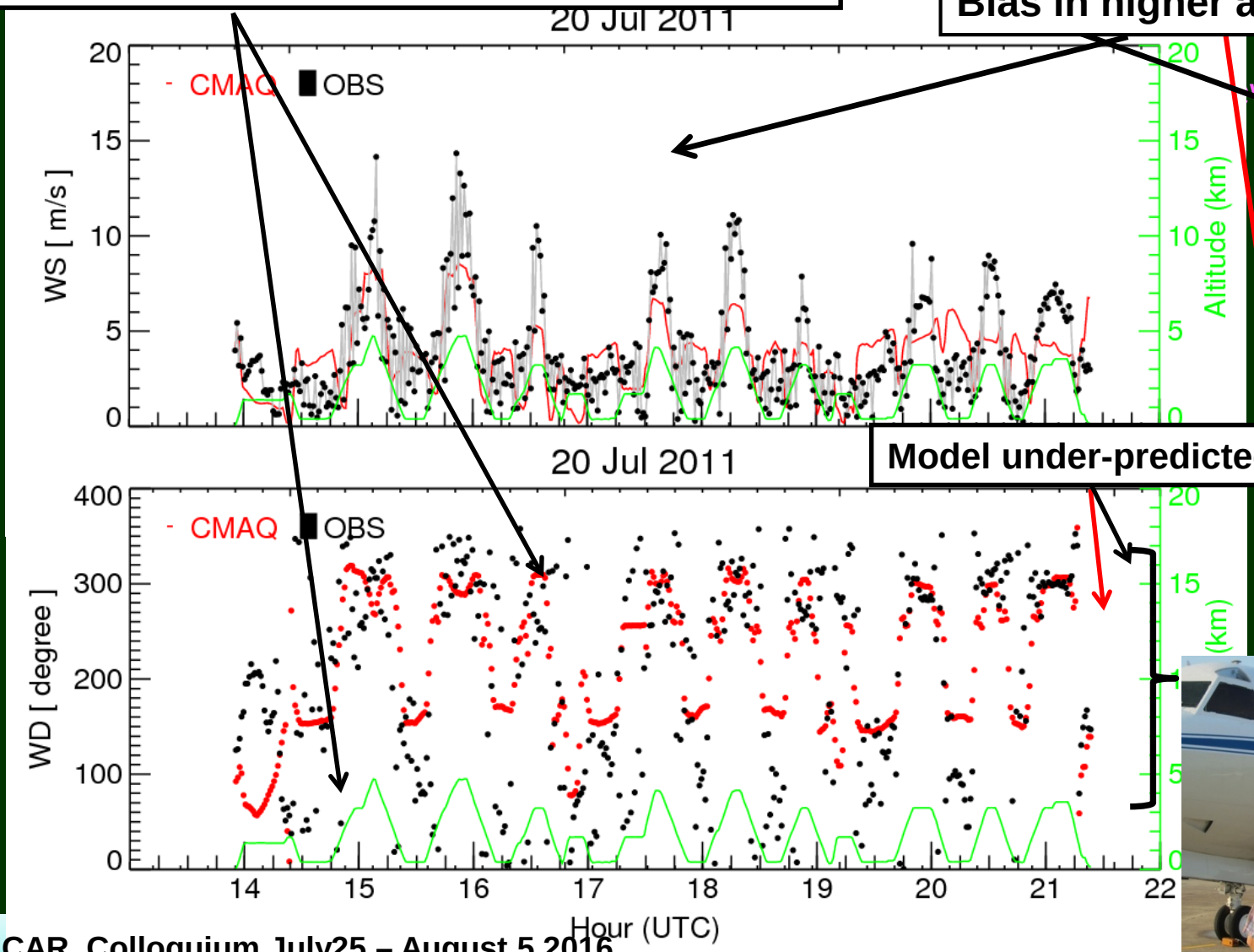
Φ_m the non-dimensional stability function
h height within surface layer
L Monin-Obukhov length

Investigate processes near PBL top

Comparison of Wind along flight track of P3B on July 20 2011

Less turbulence may not matter as PBL well-mixed, shallow-convection may matter.

More frequent -ve Bias in higher altitudes

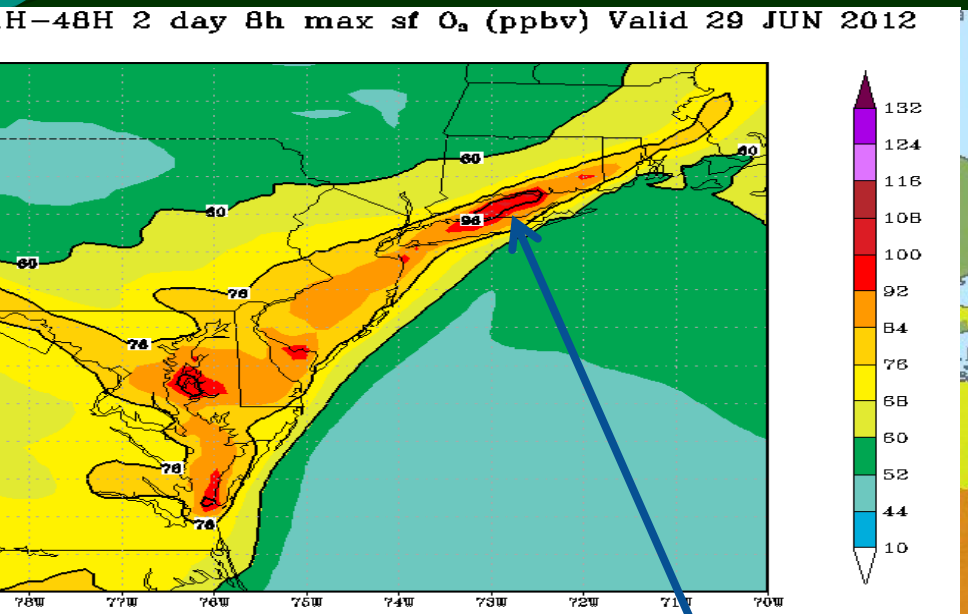


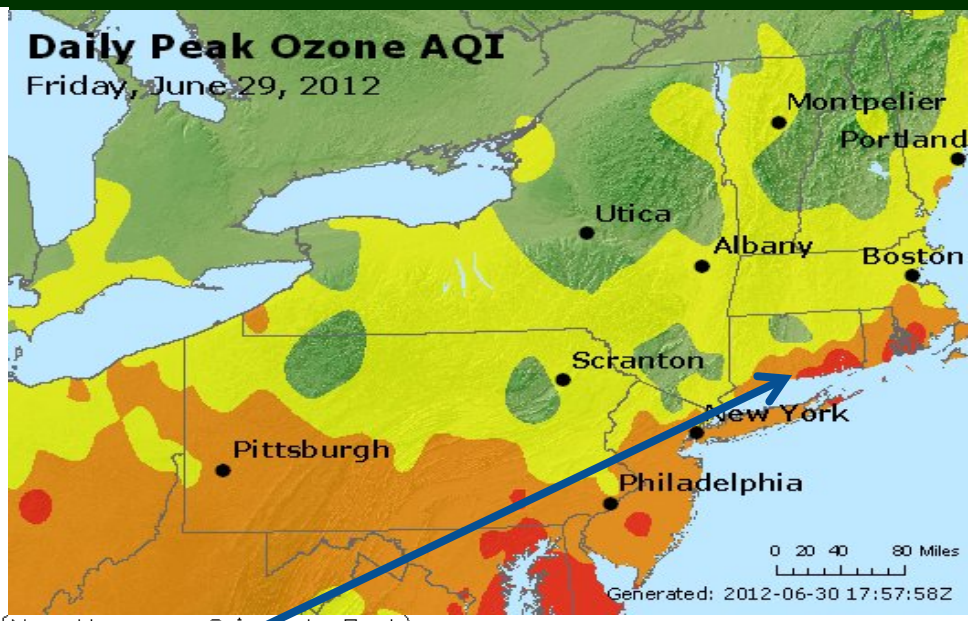
-ve bias in PBL top venting

Model under-predicted wind shear

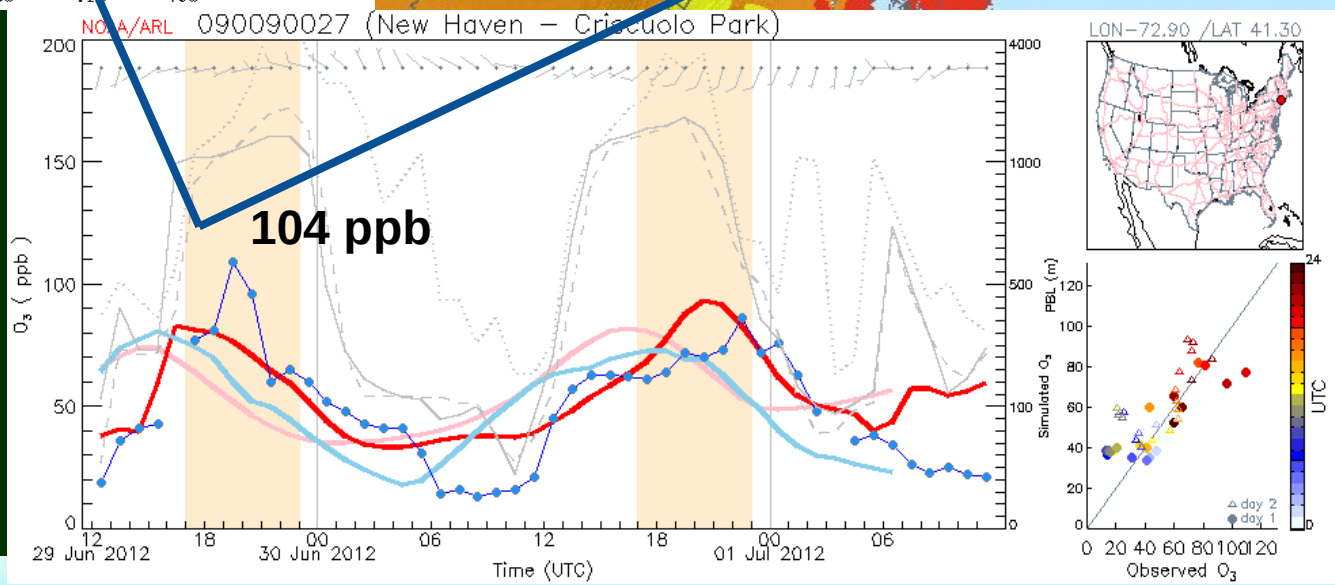
Hottest day last summer?

June 29 2012 – a hot day





- Pre-frontal trough with southwest winds along coast
- Forecast 77 ppb at Groton, verified at 104 ppb!
- Quasi-stationary pre-frontal troughs?



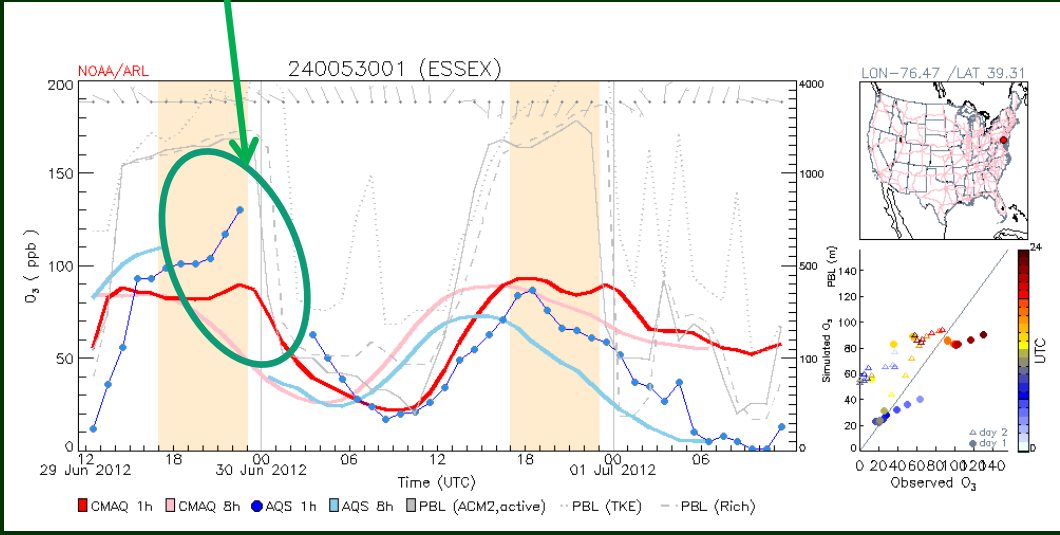
Courtesy: Michael Geigert (CTDEP)

June 29, 2012, Maryland's worst day of the season

- All 18 MDE monitors ≥ 85 ppb for 8-hour average
- Highest 8-hour average was 113 ppb at Horn Point monitor on the Eastern Shore
- Highest 1-hour average was 130 ppb at Essex in the Baltimore Metro region

Pointed developers to study

- ➢PBL processes
- ➢Convective & turbulent mixing
- ➢Land-Sea interaction
- ➢Fine features: e.g. terrain, urban

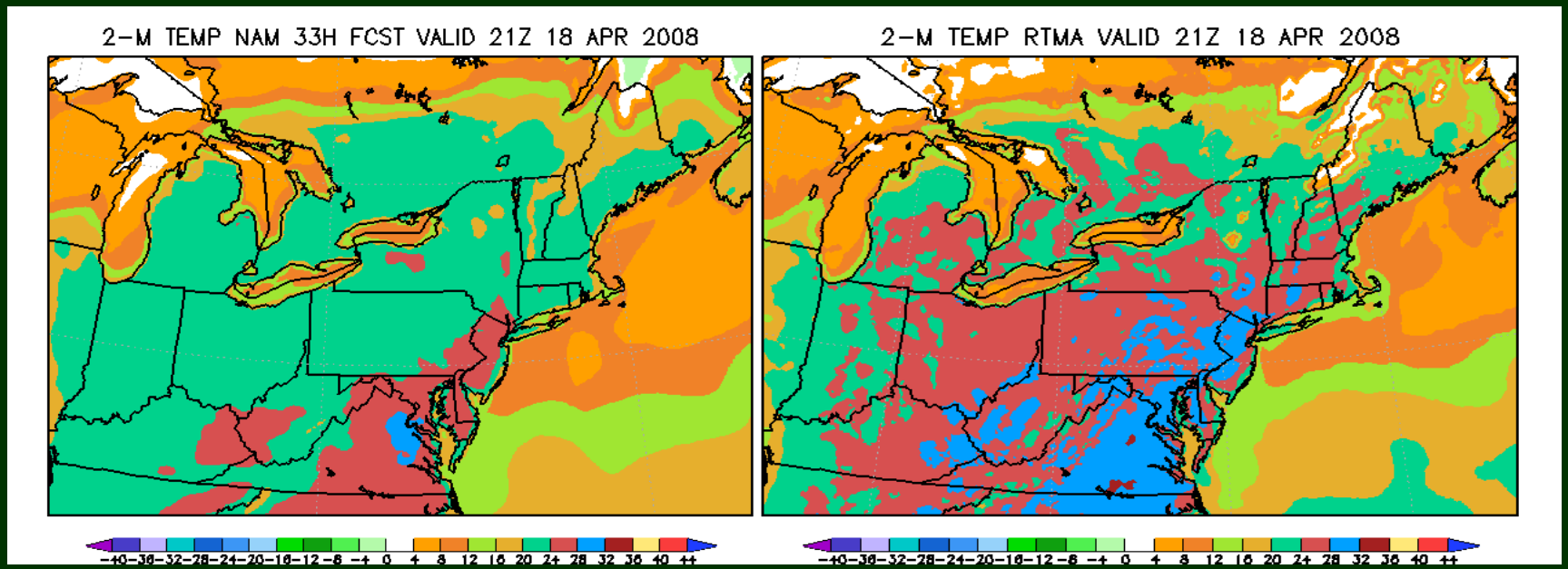


Serious Ozone Model Under-prediction for April 2008

- Exceedances of the new standard already occurred on April 18-19 throughout the Northeast.
- NOAA model predictions from northern NJ to Maine were significantly low for that event.
- Today's NOAA model prediction, April 23, 2008, is for 55-65ppb 8-hour ozone average in CT.
- MAQSIP* model predictions are even lower (<60 ppb).
- As of 19z, our Cornwall site has reached 80ppb for 2 hours and may exceed 80 ppb for the the 8-hour average!
- Temperatures for both events have been in the low 80s, which is not usually high enough for these ozone levels in the summer.
- Could this be a biogenic emission issue?

Courtesy:
Michael Geigert
(CTDEP)

April 18-19, 2008 Case Study with a variant of NAM for testing
By NCEP Land Surface Modeling team,
AQM-team reported NAM is cool and moist by
as much as 4-8 ^{o}C over New England



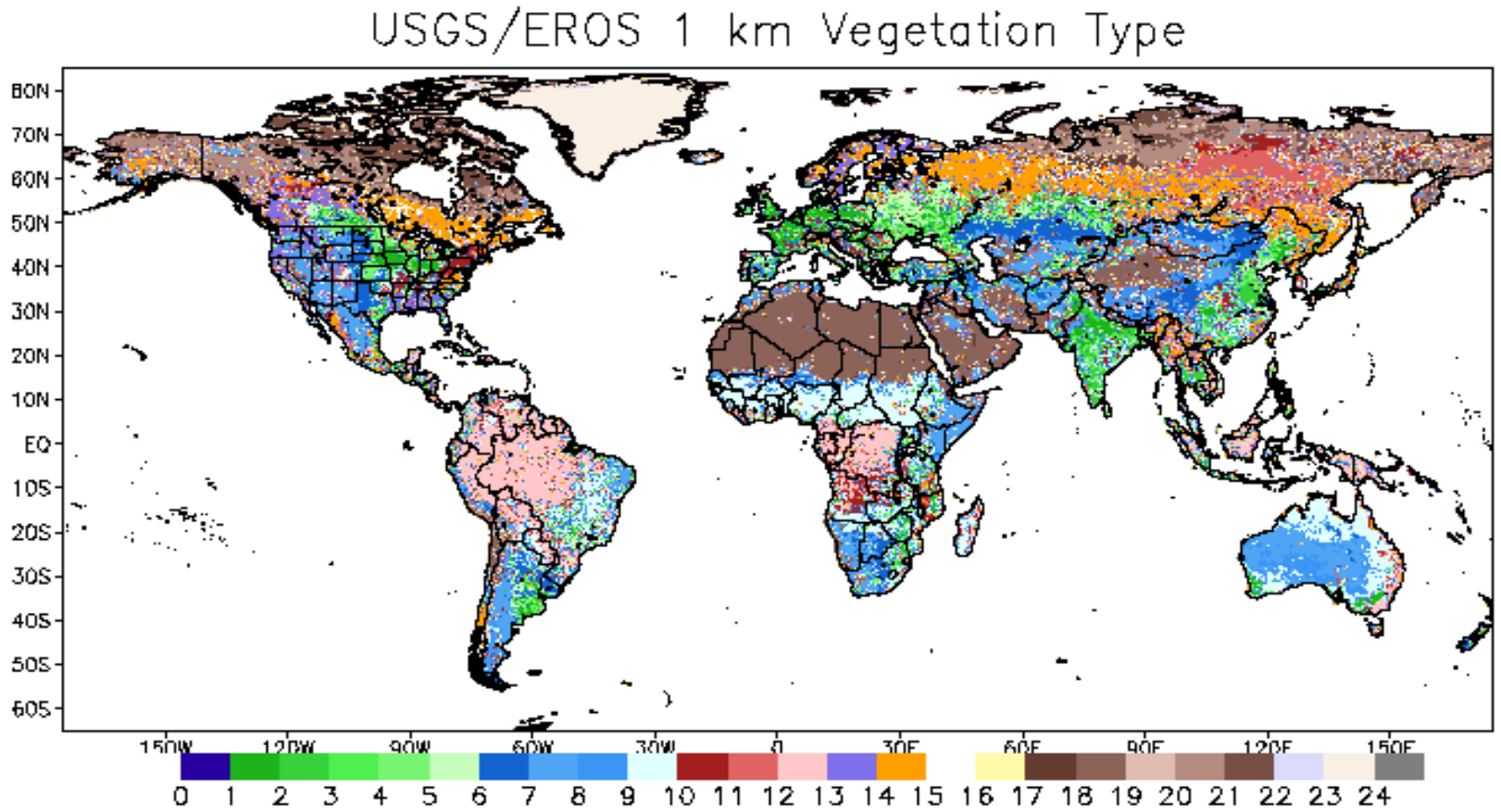
NAM 12 km

RTMA 5 km

Courtesy: NCEP
LSM & AQM teams

•NAM is colder than RTMA over NE by 4° C under clear skies -- collocation with ozone exceedences

Land Surface Model points to land cover as a factor causing high O3 April 18-19, 2008



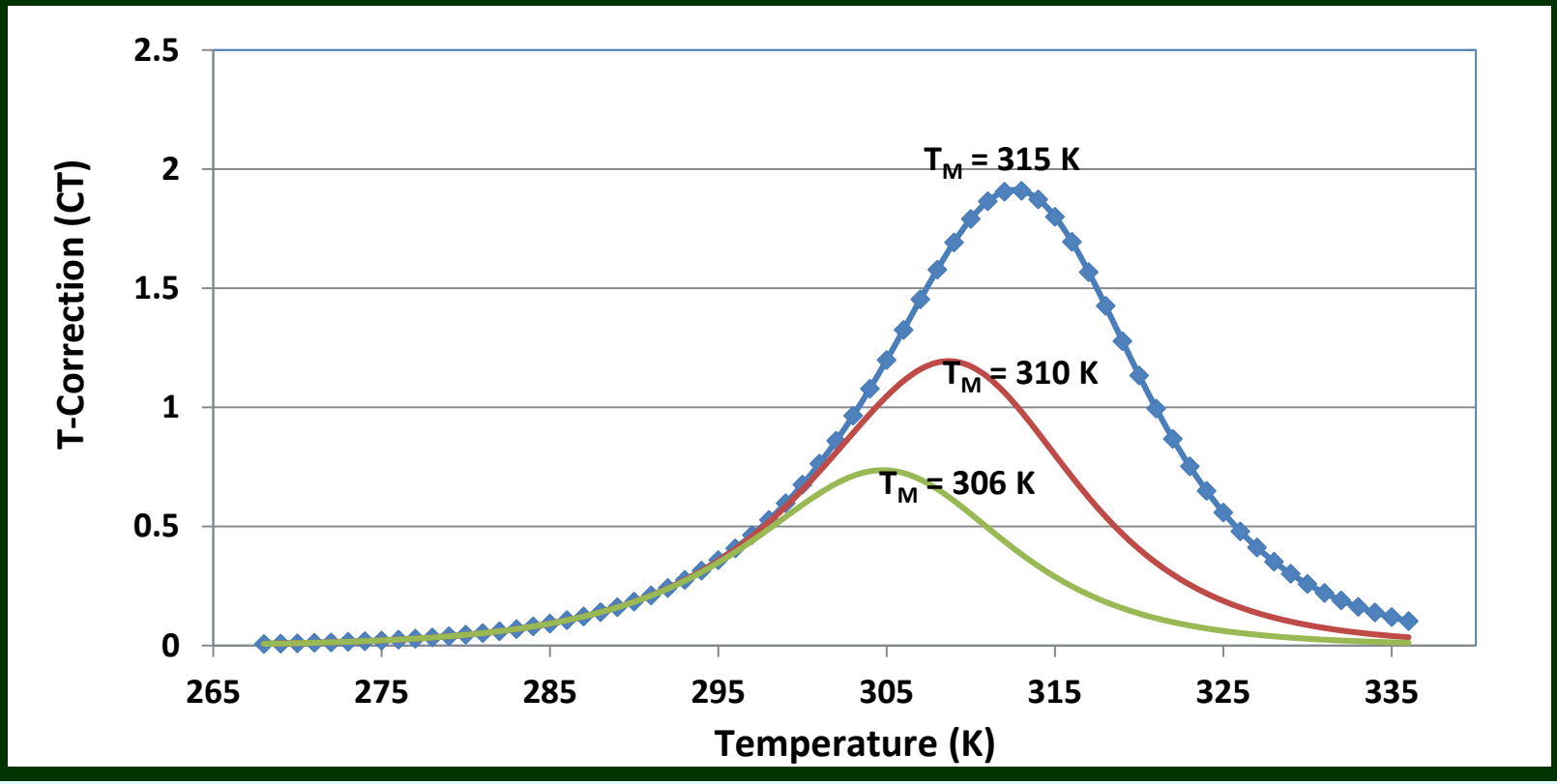
Isoprene emissions in BEIS -- T sensitive

EMIS = SEMIS X C_T X C_L

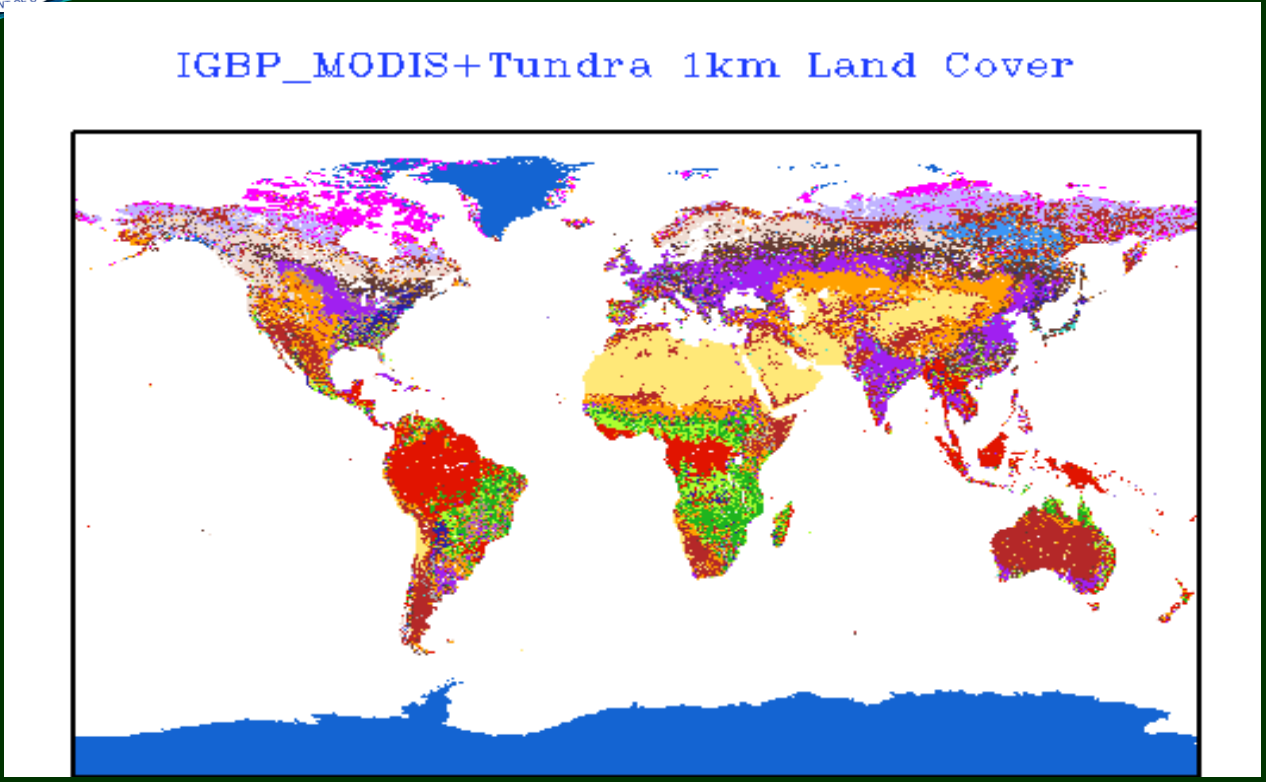
SEMIS = normalized emissions;

C_T = temperature correction factor;

C_L = radiation correction factor;



NAM changed from USGS Land-use to IGBP Land-use category



2. Evergreen Broadleaf Forests
3. Deciduous Needleleaf Forests
4. Deciduous Broadleaf Forests
5. Mixed Forests
6. Closed Shrublands
7. Open Shrublands
8. Woody Savannas
9. Savannas
10. Grasslands
11. Permanent Wetlands
13. Urban and Built-Up Lands
14. Mixed Cropland/Natural Vegetation
15. Glacial Ice
16. Bare land (barren)
17. Water Bodies
18. Wooded Tundra
19. Mixed Tundra
20. Bare Ground Tundra

To accommodate more frequent updates of Leaf Area Idex (LAI) and land-cover (e.g. snow cover), Bi-weekly climatology observed from MODIS is under testing at NCEP

NOAA model prediction, April 23, 2008, is for 55-65ppb 8-hour ozone average in CT.

- **As of 19z, our Cornwall site has reached 80ppb for 2 hours and may exceed 80 ppb for the the 8-hour average!**

Pointed developers to study

- **NAM's Land Surface Model**
- **Land Use / Land Cover**
  e.g. Greenness fraction
- **Early leafing & biogenic emission**
- **Isoprene emission sensitivity to temperature**

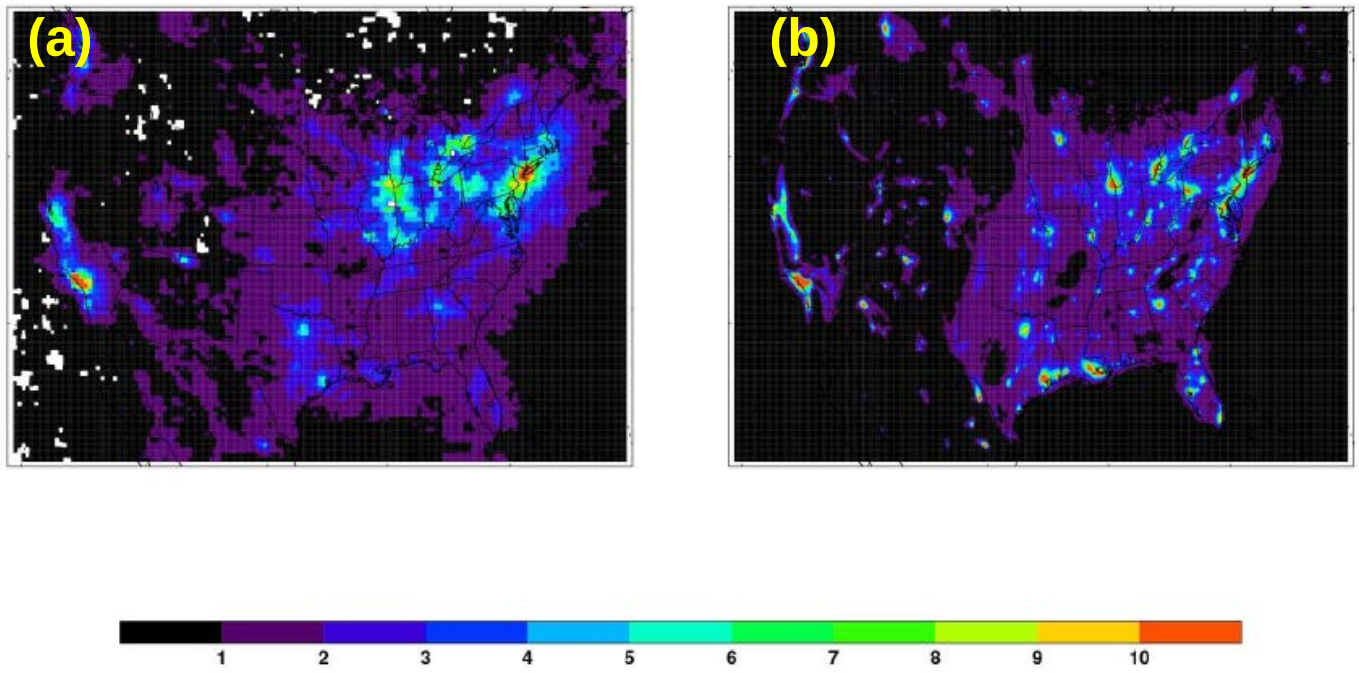
Recommendation in Exp-NAM used for the April 18-19 2008 NAQFC Case Study w.r.t. the operational NAM:

1. Relate uptake water from roots with root zone soil temperature and only apply to deciduous broadleaf forest.
2. New Shallow Convection scheme
3. Let ETP (potential evaporation) decrease linearly with Bulk Richardson # under stable condition, and weighted by snow coverage.
4. Let DQSDT2 (slope of saturated humidity function w.r.t .temperature) decrease linearly with snow coverage.

5. Other miscellaneous changes

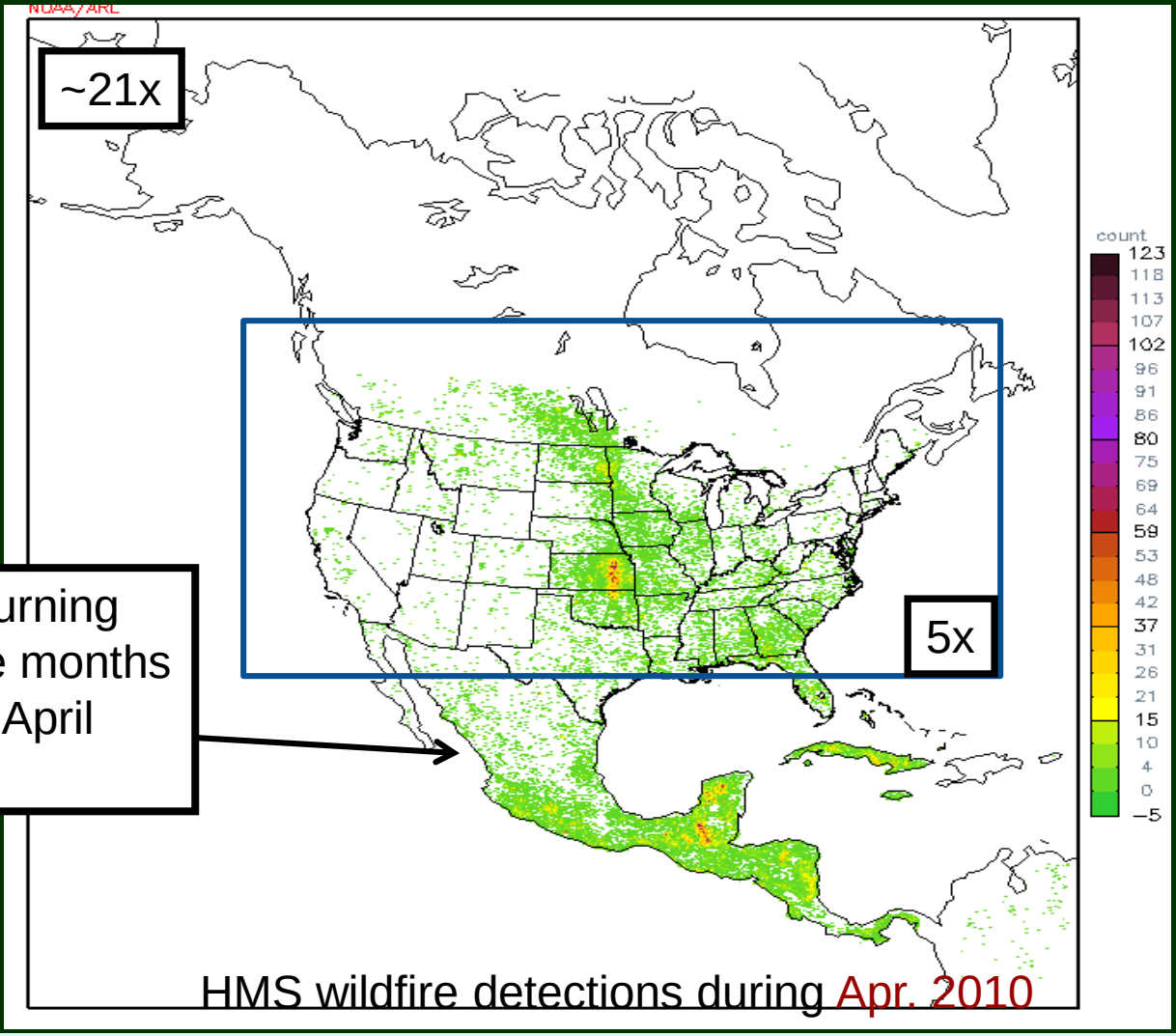
Courtesy: NCEP
LSM & AQM teams

Investigate NOx emission – O3 precursor from: (a) GOME-2 and (b) model



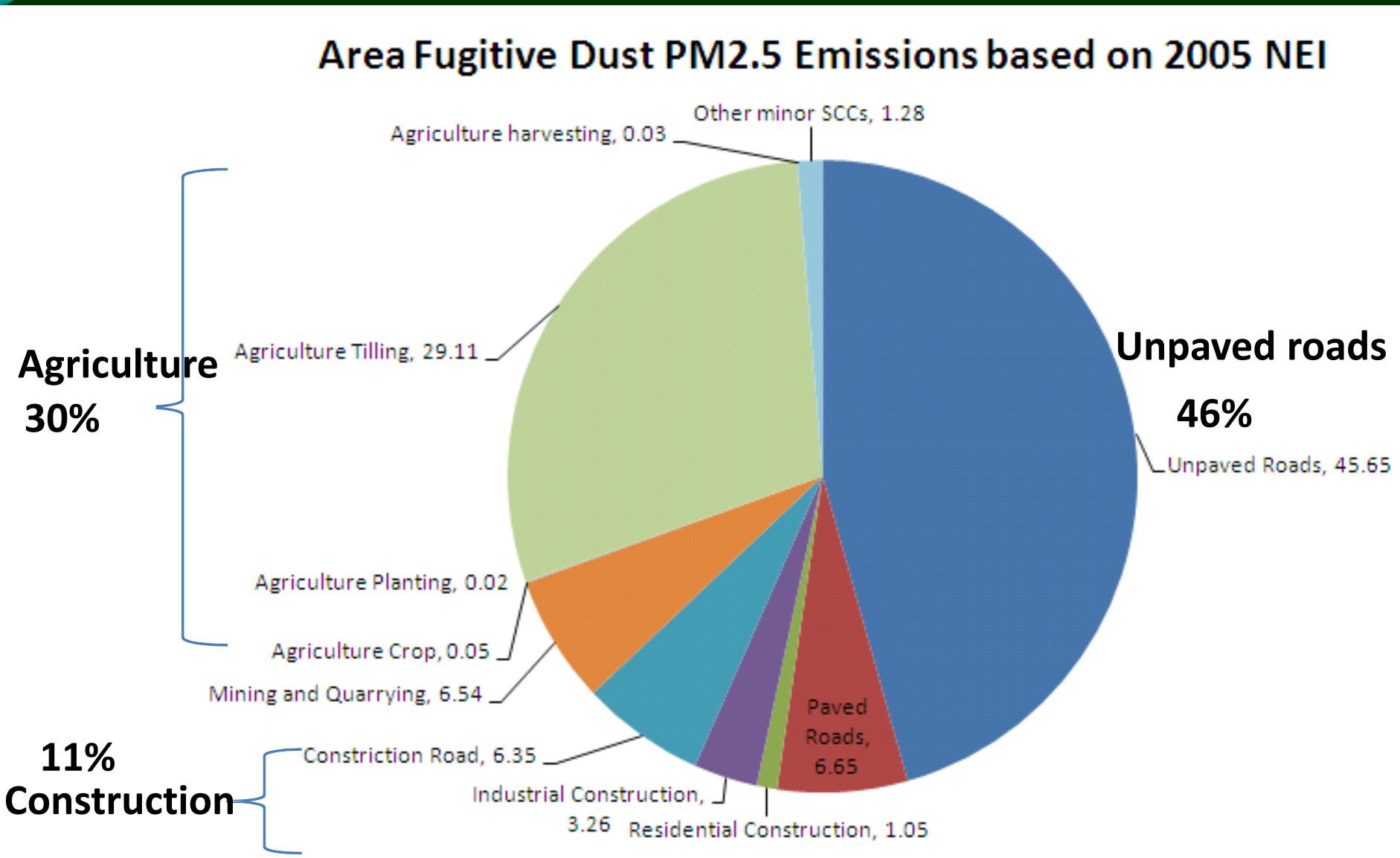
CMAQ overpredicts NO_2 columns over the urban region of the southern US, but it underpredicts NO_2 columns over the rural region

Emission should include Exo- and intra-domain wild fires

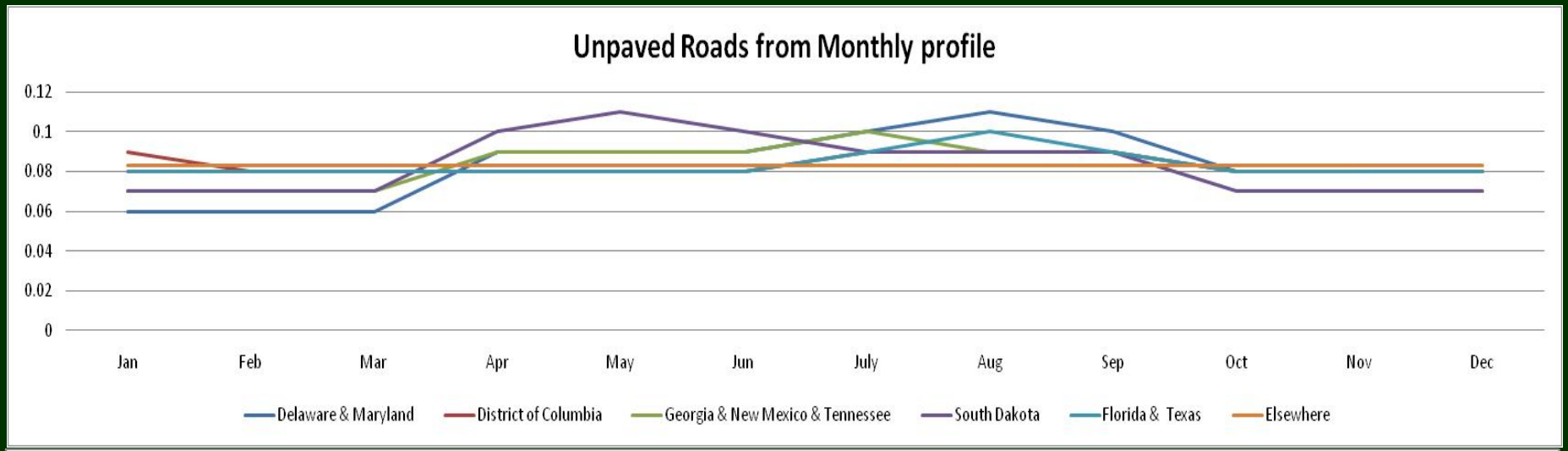


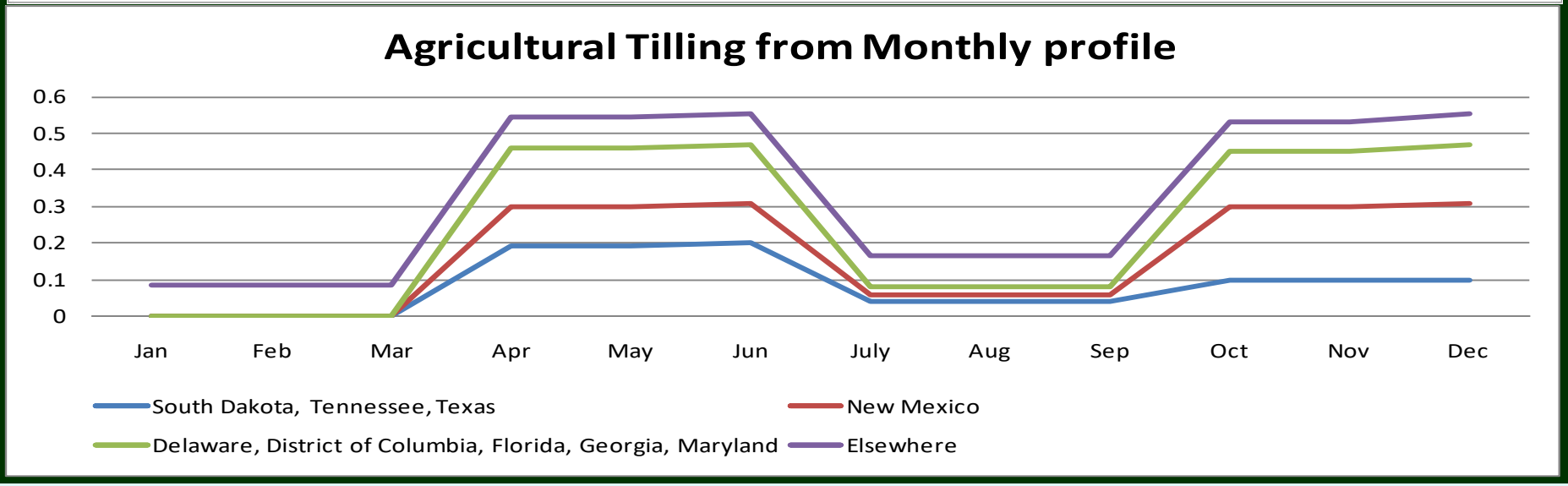
Agricultural burning prevails in the months of March and April in Mexico

Deficiencies in PM emissions in NAQFC?

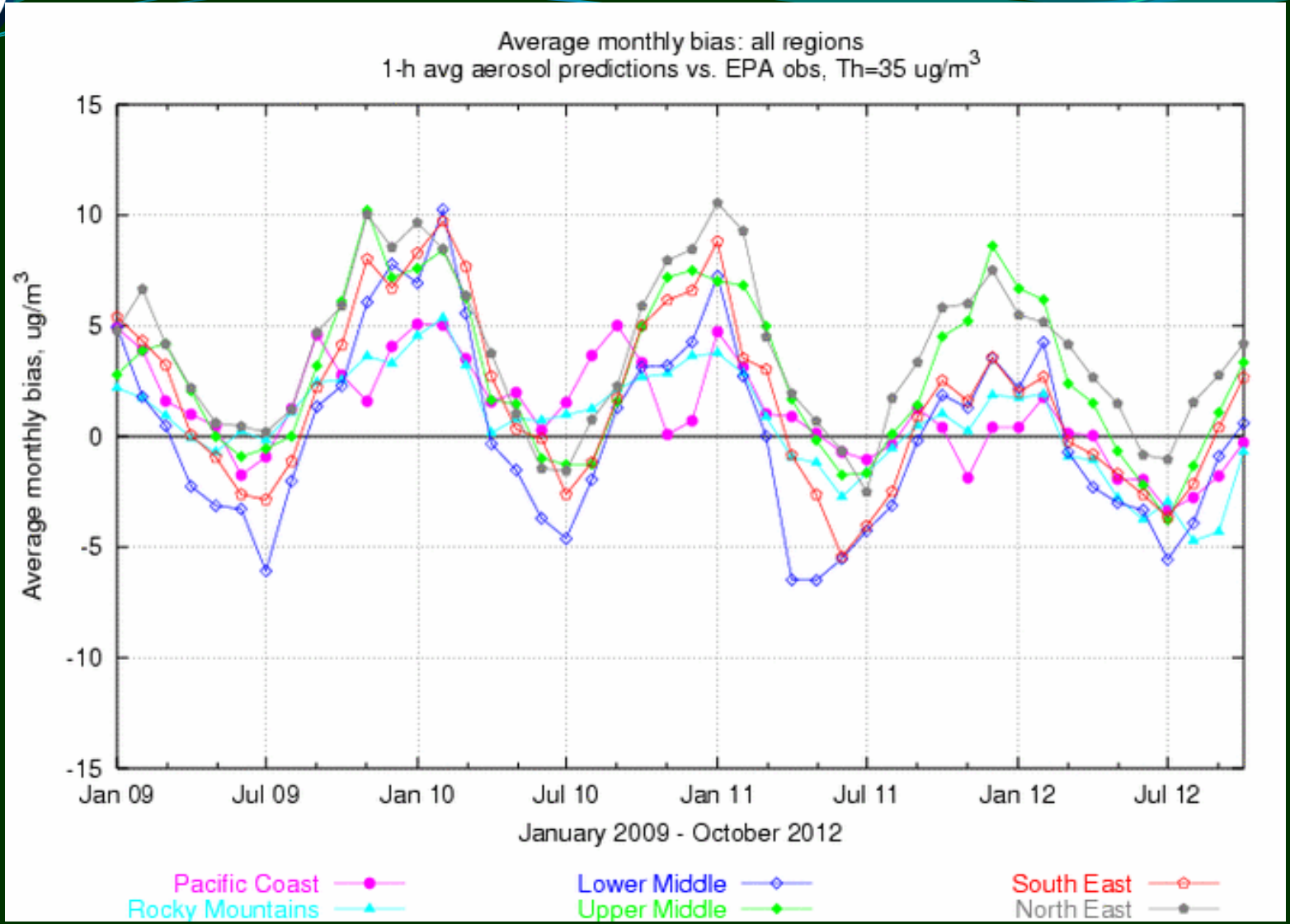


Investigation on poor dust emission temporalization





PM2.5 forecast: High bias in winter and low bias in summer

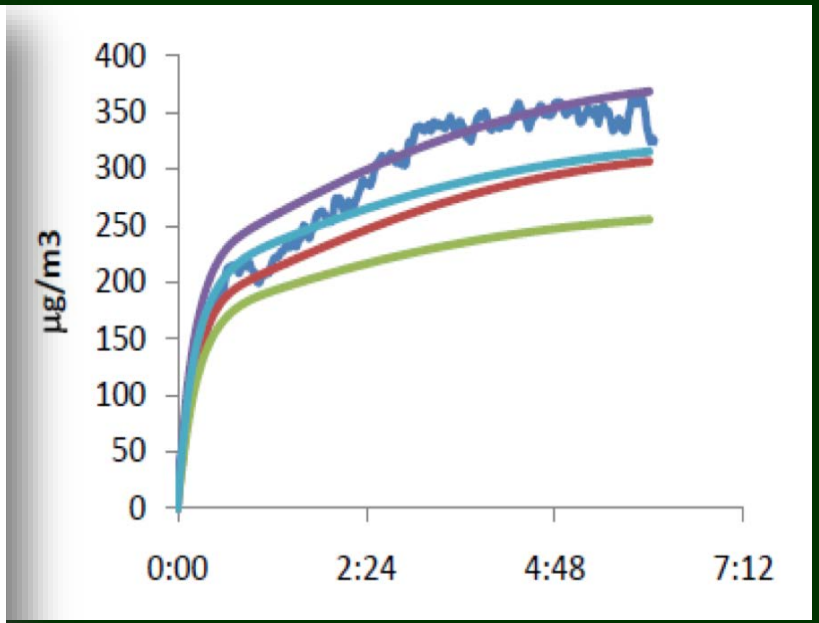


CMAQ box modeling studies of SOA formation

➢ BOX MODEL:
CMAQ 4.7 simulations for each experiment:

1. CB05 AERO4
2. CB05 AERO5
3. SAPRC99 AERO4
4. SAPRC99 AERO5

- 4 X 4 cell grid located in Valencia, Spain (LAT: 39, LON: 0)
- Only gas phase chemistry and aerosol formation are considered



Experimental data (blue) Saprc99_ae4 (green), CB05_ae4 (red), Saprc99_ae5 (light blue) and CB05_ae5 (purple)

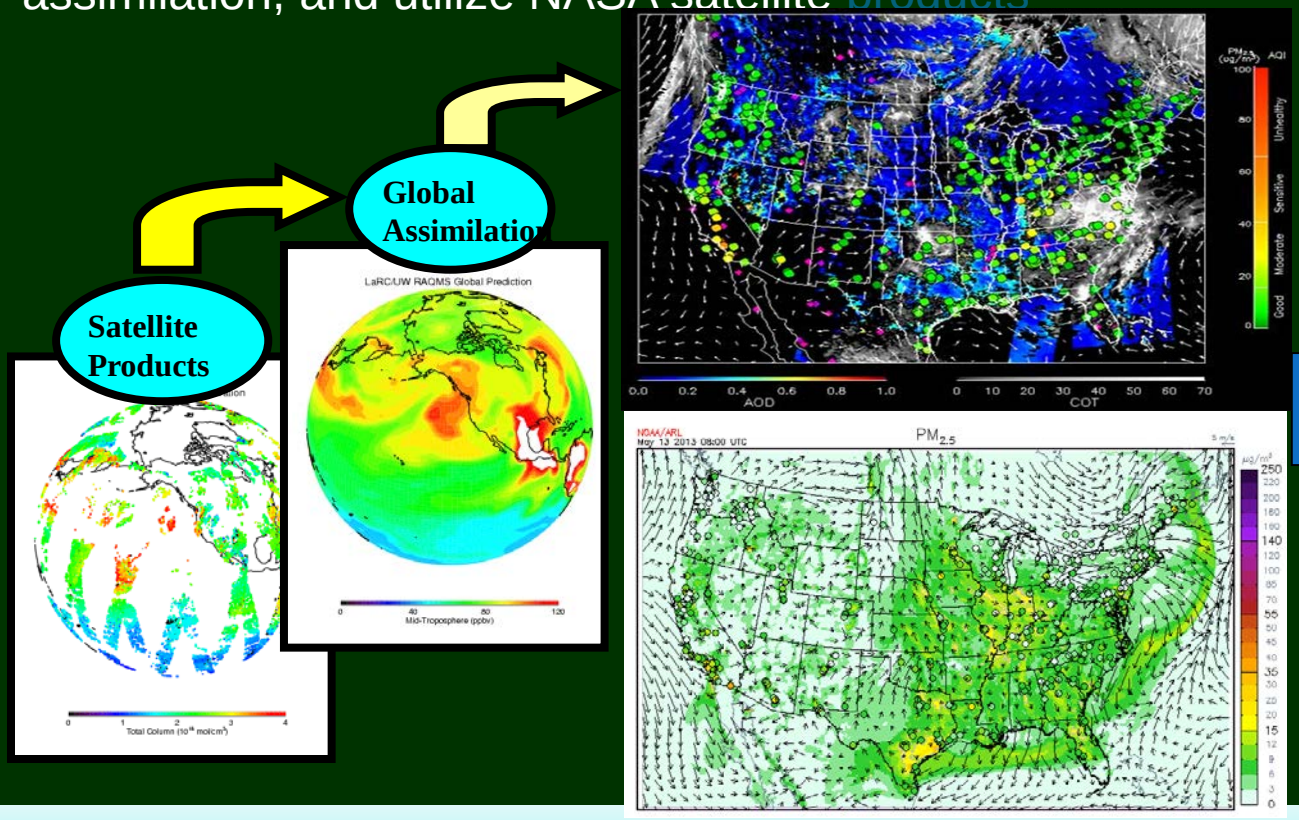
Air Quality Reanalysis (*Translating Research to Services*)

Greg Carmichael + others

Stand-up a demonstration of an operational AQ reanalysis (WRF-CMAQ-GSI - expandable and updatable - candidates PM2.5, NO_2, O_3, CO, AOD)

Including a data dissemination system to distribute reanalysis field downloads – *product: user-guide and web-based data portal*

Builds upon AQAST expertise in satellite retrievals, modeling and assimilation, and utilize NASA satellite products



Applications

+ AQ Assessments

+ State Implementation Plan Modeling

+ Rapid deployment of on-demand rapid-respond forecasting; e.g., Methane leakage from fracking

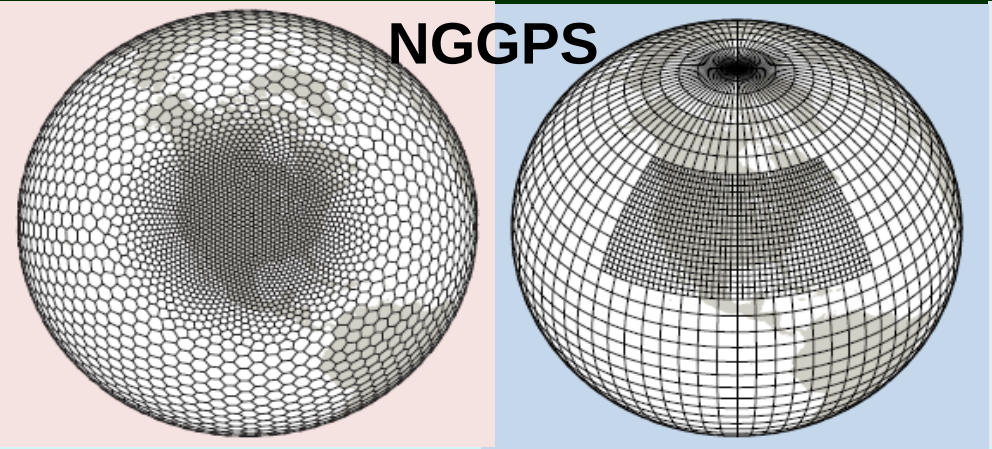
+ Demonstration of the impact of observations on AQ distributions

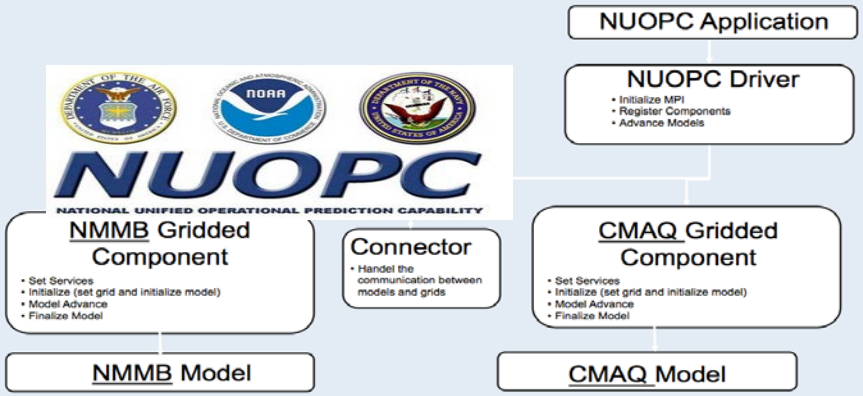
12 km CMAQ Regional Assimilation

Summary:

When a local agency forecaster speaks we listen and respond. We often proactively tackle emerging problems such as tightening National Ambient Air Quality Standards and the implementation new Air Pollution Rules.

NAQFC-para qualifies for upgrade only all metrics have been proven improved with multiple seasons testing





Extra slide

National Air Quality Forecasting Capability (NAQFC) Implementation Team Members

NOAA

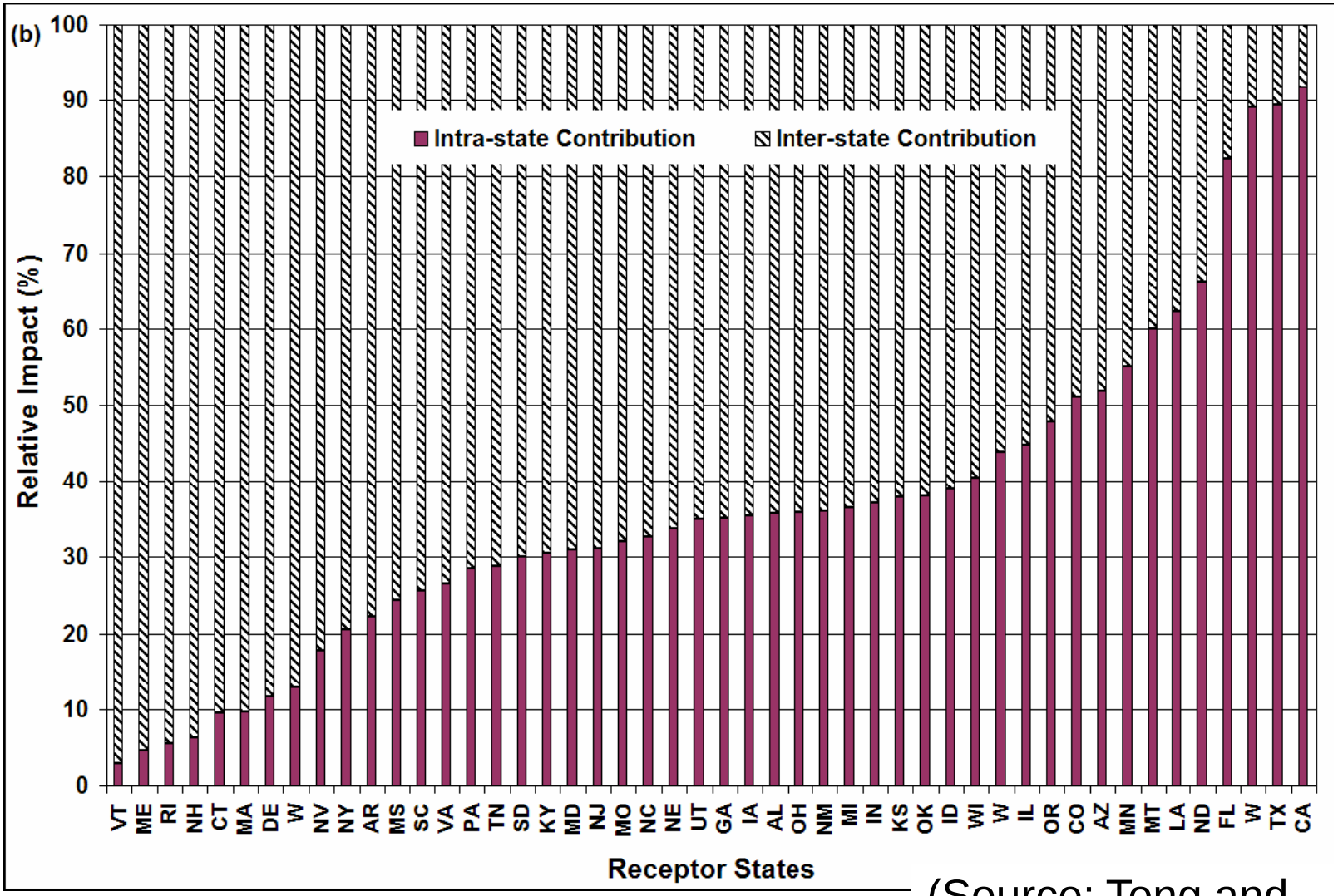
•OST	Ivanka Stajner	Program Manager
•OST/MDL	Jerry Gorline; Marc Saccucci	Verification; NDGD Product
•OCWWS	Jannie Ferrell	Program Support
•NCDC	Alan Hall	Product Archiving
•NCEP	Jeff McQueen, Jianping Huang	NAM meteorology impact CMAQ & product dissimilation
•ARL	Pius Lee, Daniel Tong, Hyuncheol Kim, Li Pan	Forecasting Science, emission & forecasting improvement
•NESDIS	Mark Ruminski	HMS product

EPA

•OAQPS	Phil Dickerson, Brad Johns, John White	AIRNow network & timely reporting of observed data

Glossary: Air Resources Laboratory (ARL); Community Air Quality Multi-scale Model (CMAQ); Hazard Mapping System (HMS); Meteorological Development Laboratory (MDL); North American Model (NAM); National Climatic Data Center (NCDC); National Centers for Environmental Prediction (NCEP); National Digital Guidance Database (NDGD); NOAA's Satellite and Information Service (NESDIS);Office of Air Quality Planning and Standards (OAQPS); Office of Climate, Water and Weather Service (OCWWS); Office of Science and Technology (OST)

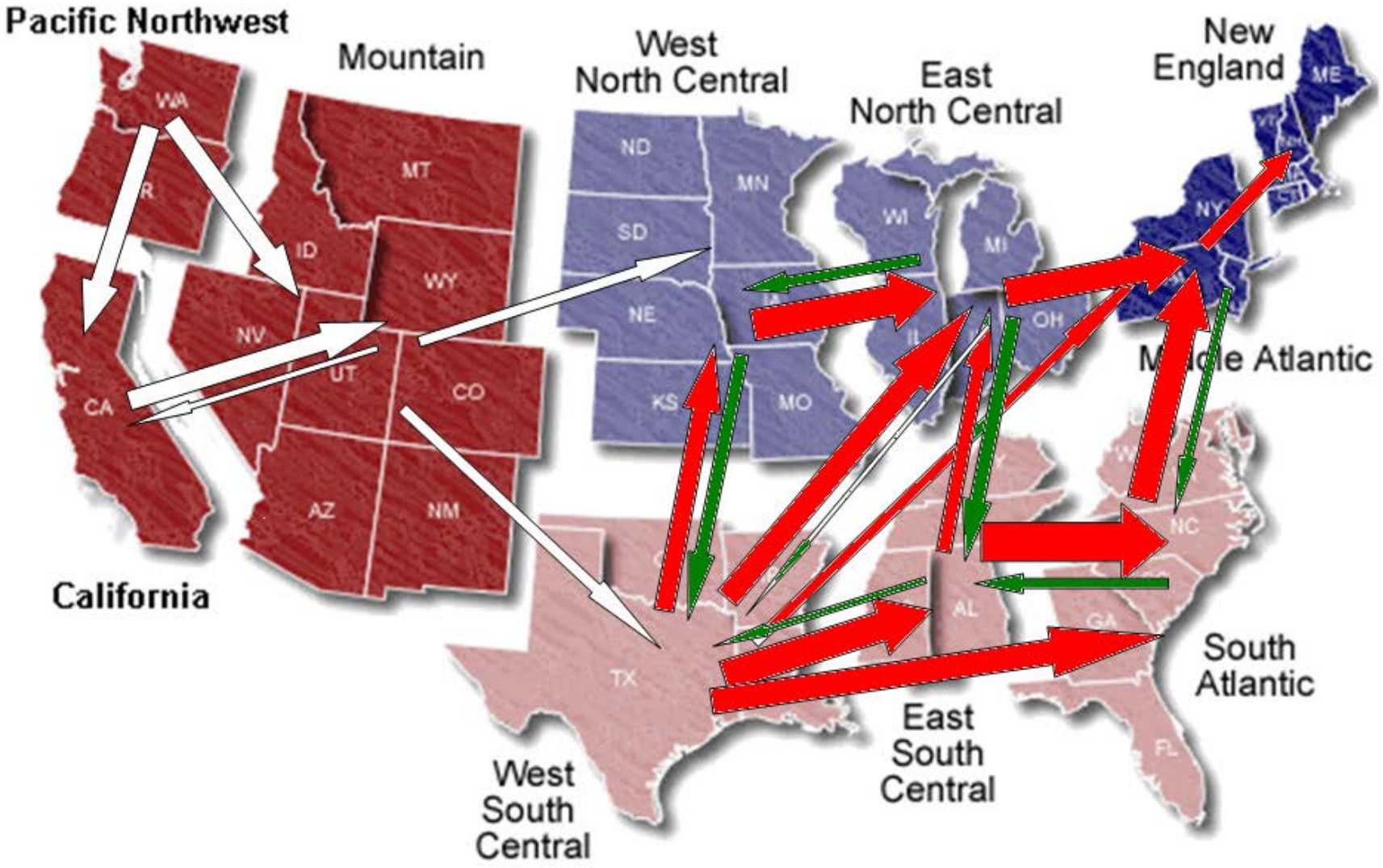
Contributions from intra- and inter-state NO_x emissions to surface O_3 concentrations in each state (%).



MD emissions contribute < 33% of MD surface Ozone

(Source: Tong and Mauzerall, Env. Sci. & Tech, 2008)

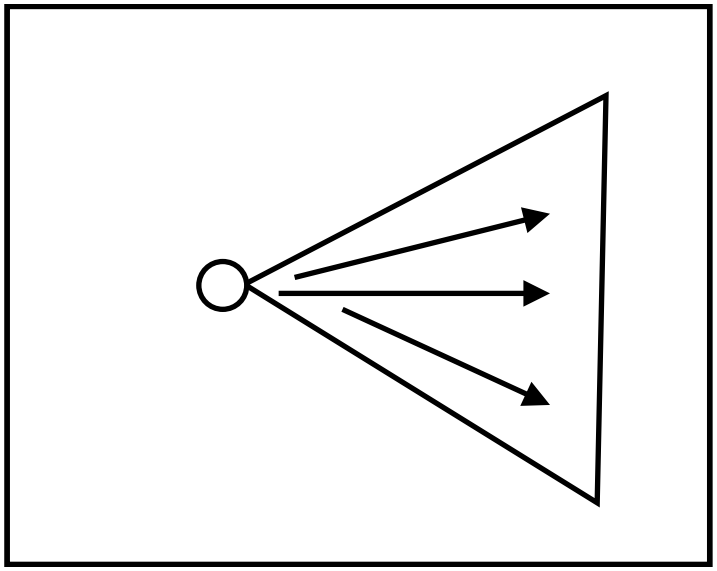
Regional Transport of Surface O_3



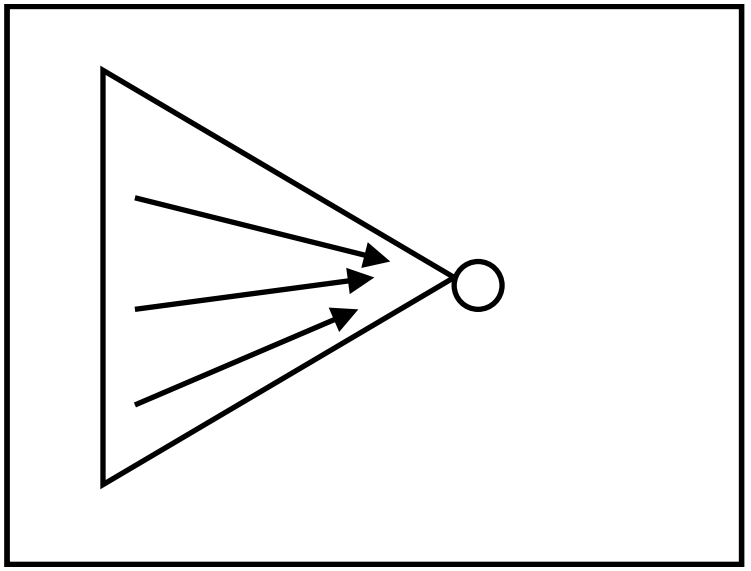
(Source: Tong et al., Env. Int'l, 2009)

Source attribution: Adjoint sensitivity analysis

Direct sensitivity analysis is a source-oriented approach.



Adjoint sensitivity analysis is a receptor/target-oriented approach.



Contribution: Tianfeng Chai