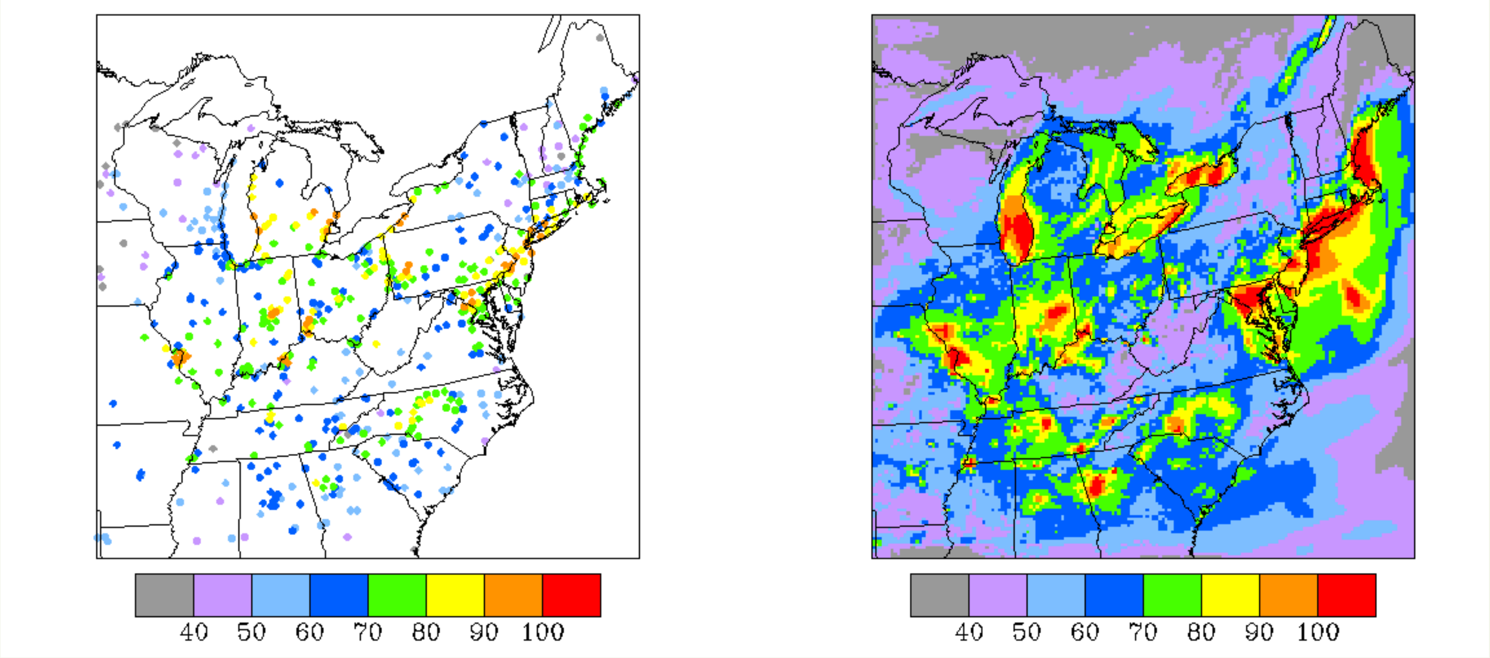
Update on NE Ozone Modeling Efforts
&
Transport Issues Facing CT



SIPRAC Meeting

June 10, 2010

Dave Wackter, CTDEP

Overview

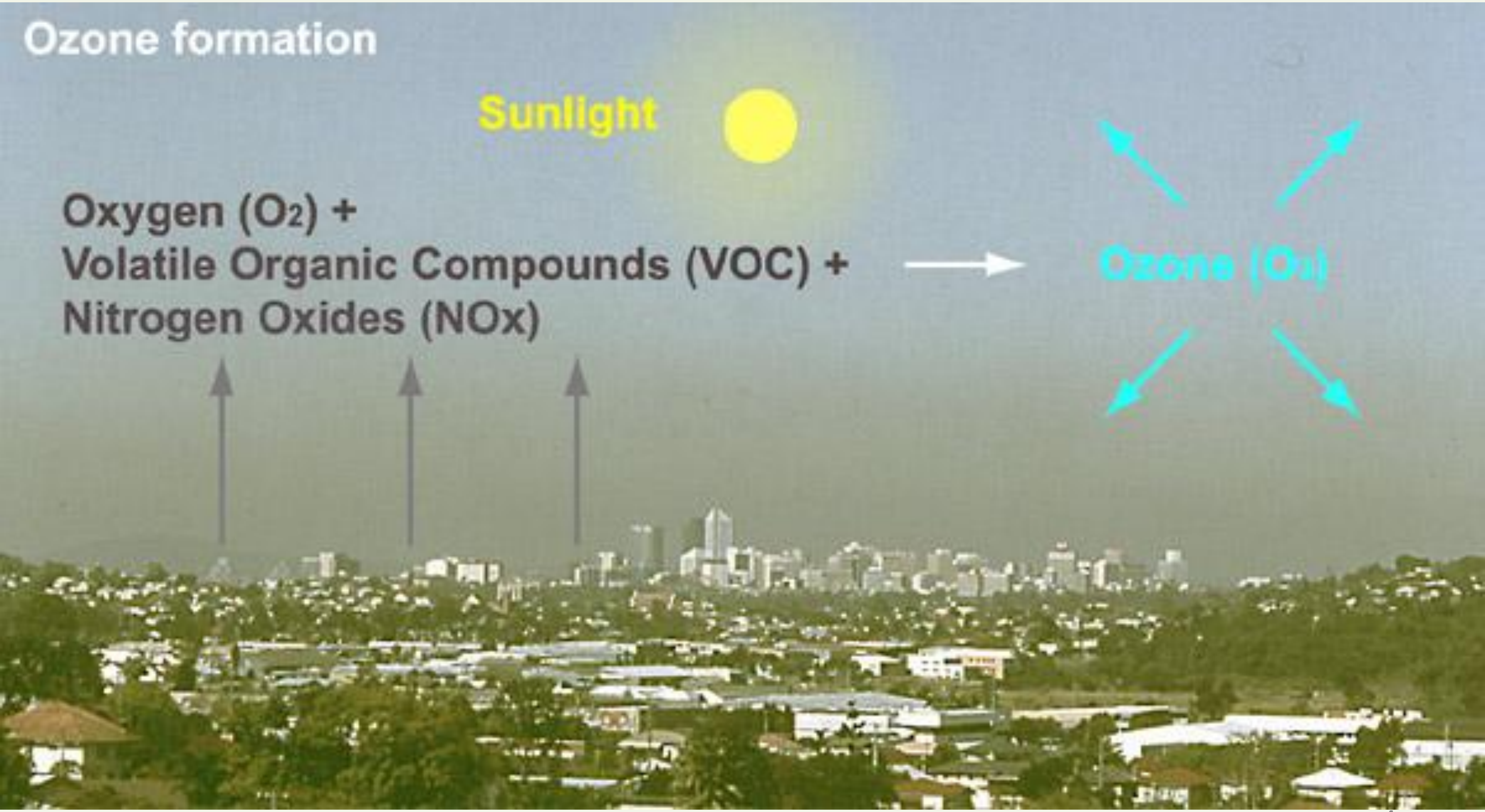
- SIP schedule for 2010 O_3 NAAQS
- Conceptual Model
  - Ozone air quality in the Northeast
  - Transport from upwind states
- Modeling Approach
  - Air pollutant emissions
  - Base and future year modeling
  - Evaluate control options
  - Attainment strategy

Anticipated NAAQS Implementation Milestones (~EPA)

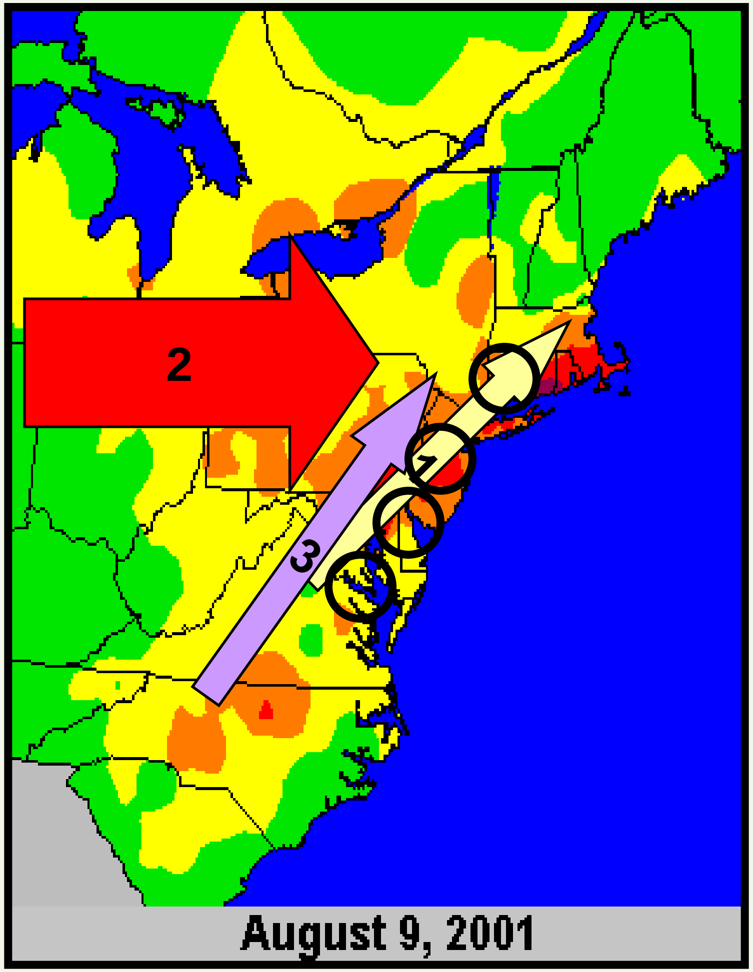
Pollutant	NAAQS Promulgation Date	Designations Effective	Attainment Demonstration Due	Attainment Date
$PM_{2.5}$ (2006)	Sept 2006	Dec 2009	Dec 2012	Dec 2014/2019
Pb	Oct 2008	Nov 2010/2011 (extra time for new monitors)	June 2012/2013	Nov 2015/2016
NO_2 (primary)	Jan 2010	Feb 2012	Aug 2013	Feb 2017
SO_2 (primary)	June 2010 (Signed June 2, 2010)	July 2012	Jan 2014	July 2017
Ozone	Aug 2010 (Proposed in FR January 19, 2010)	Aug 2011 (based on 2008-2010 data)	Dec 2013	Dec 2017 (Moderate) Dec 2020 (Serious)
CO	May 2011	June 2013	Dec 2014	May 2018
$PM_{2.5}$ (2011)	Oct 2011	Nov 2013	Nov 2016	Nov 2018/2023
NO_2 /SO_2 (Secondary)	Mar 2012	Apr 2014	Oct 2015	N/A

Underlined dates indicate court-ordered or settlement agreement deadlines.

Simplified Photochemistry of O3 Formation



Where Does Our Air Pollution Come From?



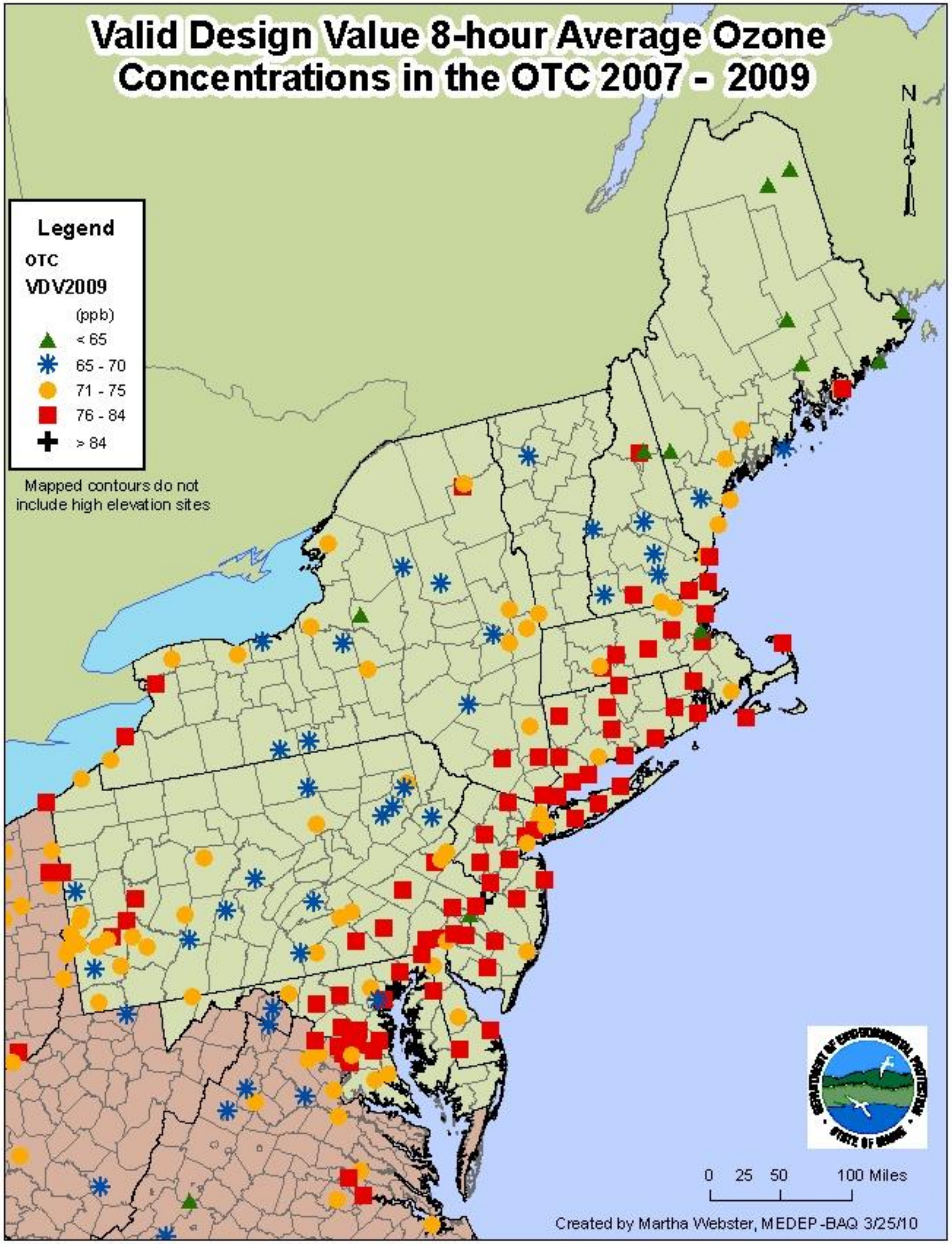
Four Distinct Parts

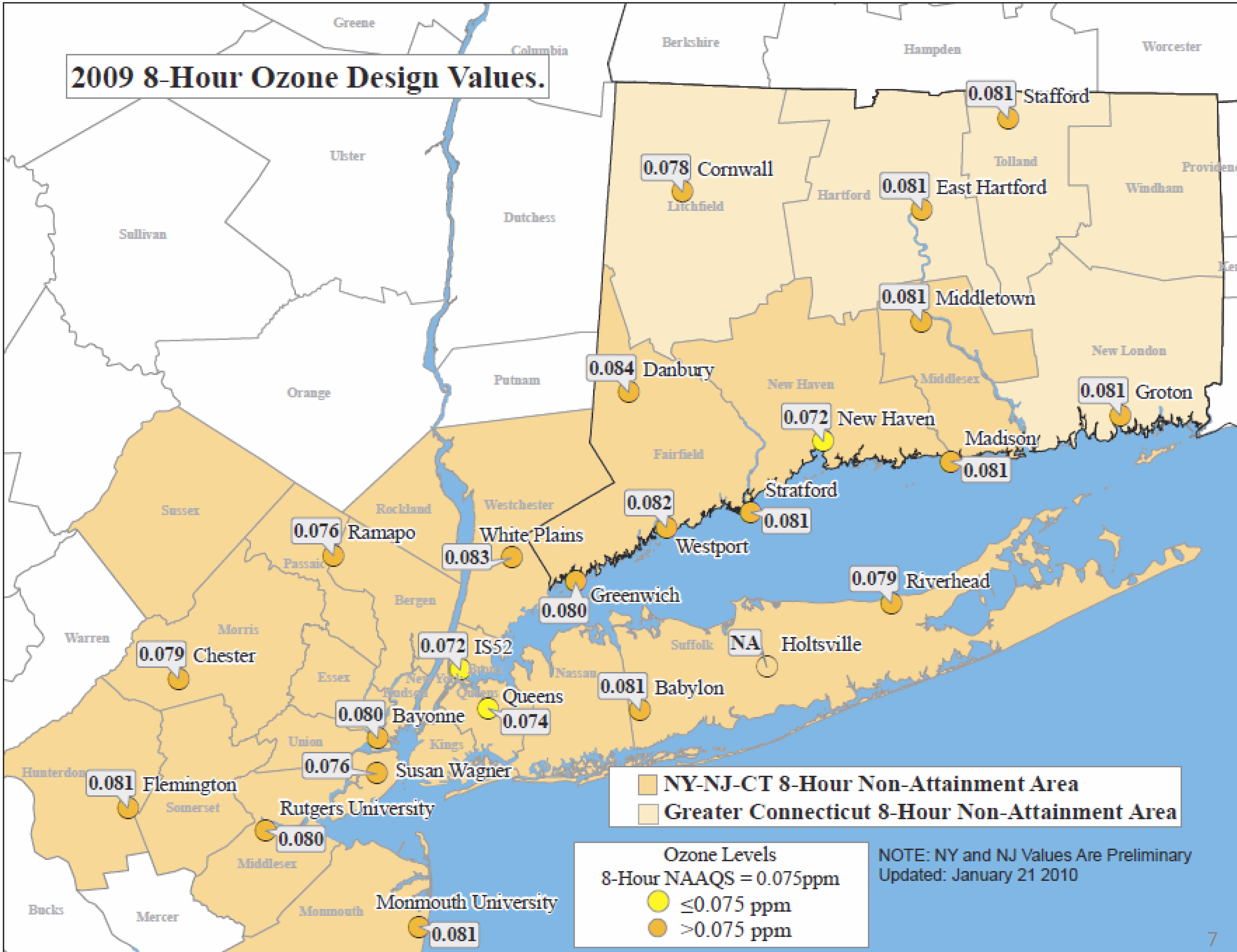
- Local emissions in Nonattainment Areas (NAAs)
- Three types of transport

1 Short range
- "Ground level" transport
- VA to MD to PA to NJ to NY to CT to MA.

2 Long range (synoptic scale)
- "Aloft" transport
- 100s of miles
- Generally from W or NW

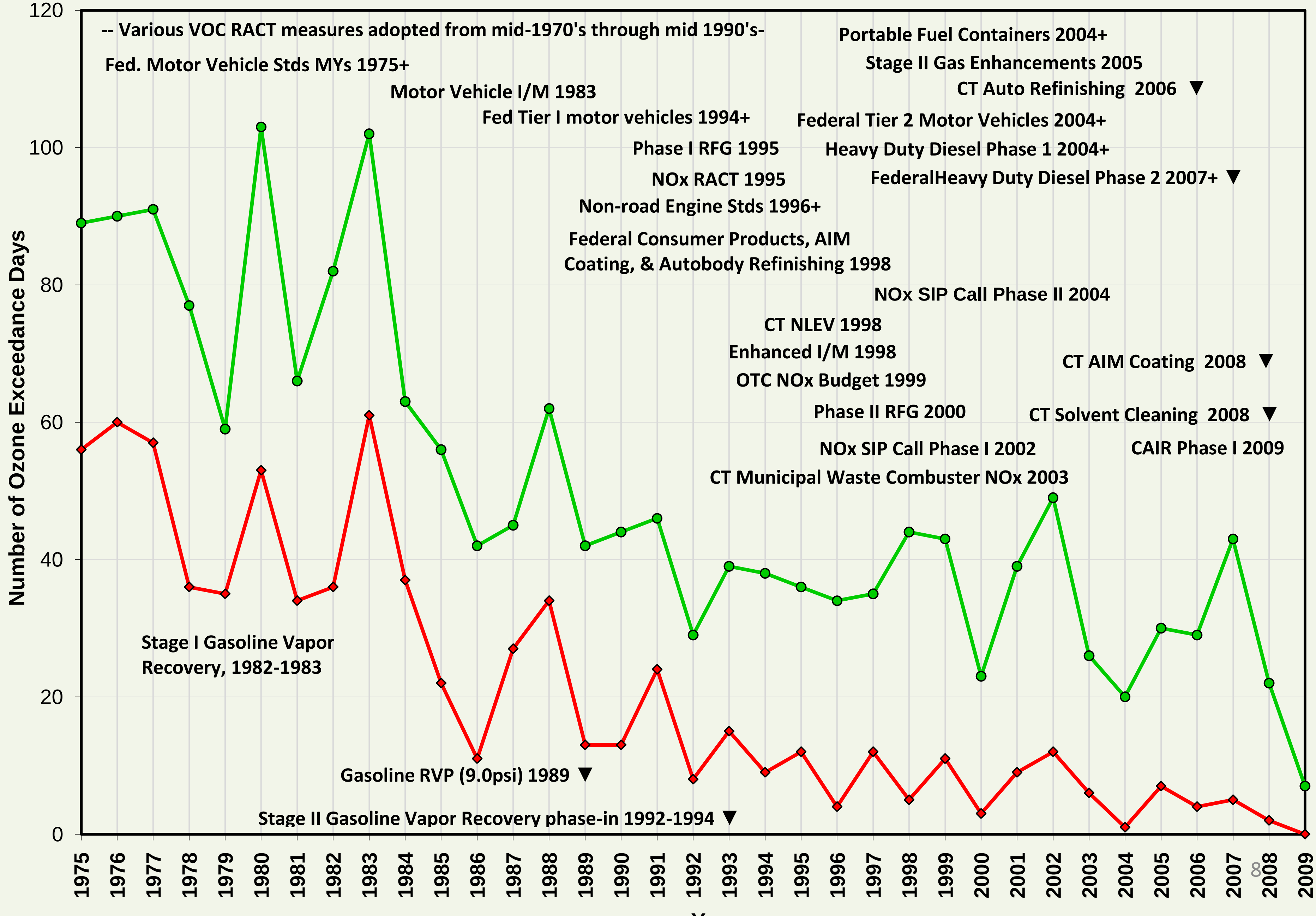
3 Low Level Night-Time Jets
- "Aloft" transport at night
- 100s of miles
- SW to NE along the Atlantic


Valid Design Value 8-hour Average Ozone Concentrations in the OTC 2007 - 2009
Legend
OTC
VDV2009
(ppb)
< 65
65 - 70
71 - 75
76 - 84
> 84
Mapped contours do not include high elevation sites
N
0 25 50 100 Miles
Created by Martha Webster, MEDEP-BAQ 3/25/10



2009 8-Hour Ozone Design Values.
Greene
Columbia
Berkshire
Hampden
Worcester
Ulster
Sullivan
Dutchess
Orange
Putnam
Litchfield
Hartford
Tolland
Windham
Providence
Kent
New London
Middlesex
New Haven
Fairfield
Sussex
Rockland
Westchester
Passaic
Bergen
Warren
Morris
Essex
Hudson
New York
Bronx
Queens
Kings
Nassau
Suffolk
Union
Hunterdon
Somerset
Middlesex
Monmouth
Bucks
Mercer
0.081 Stafford
0.078 Cornwall
0.081 East Hartford
0.081 Middletown
0.084 Danbury
0.081 Groton
0.072 New Haven
Madison 0.081
Stratford 0.081
0.082 Westport
0.076 Ramapo
0.083 White Plains
0.080 Greenwich
0.079 Riverhead
0.079 Chester
0.072 IS52
NA Holtsville
0.081 Babylon
Queens 0.074
0.080 Bayonne
0.076 Susan Wagner
0.081 Flemington
Rutgers University 0.080
Monmouth University 0.081
NY-NJ-CT 8-Hour Non-Attainment Area
Greater Connecticut 8-Hour Non-Attainment Area
Ozone Levels
8-Hour NAAQS = 0.075ppm
≤0.075 ppm
>0.075 ppm
NOTE: NY and NJ Values Are Preliminary
Updated: January 21 2010
7

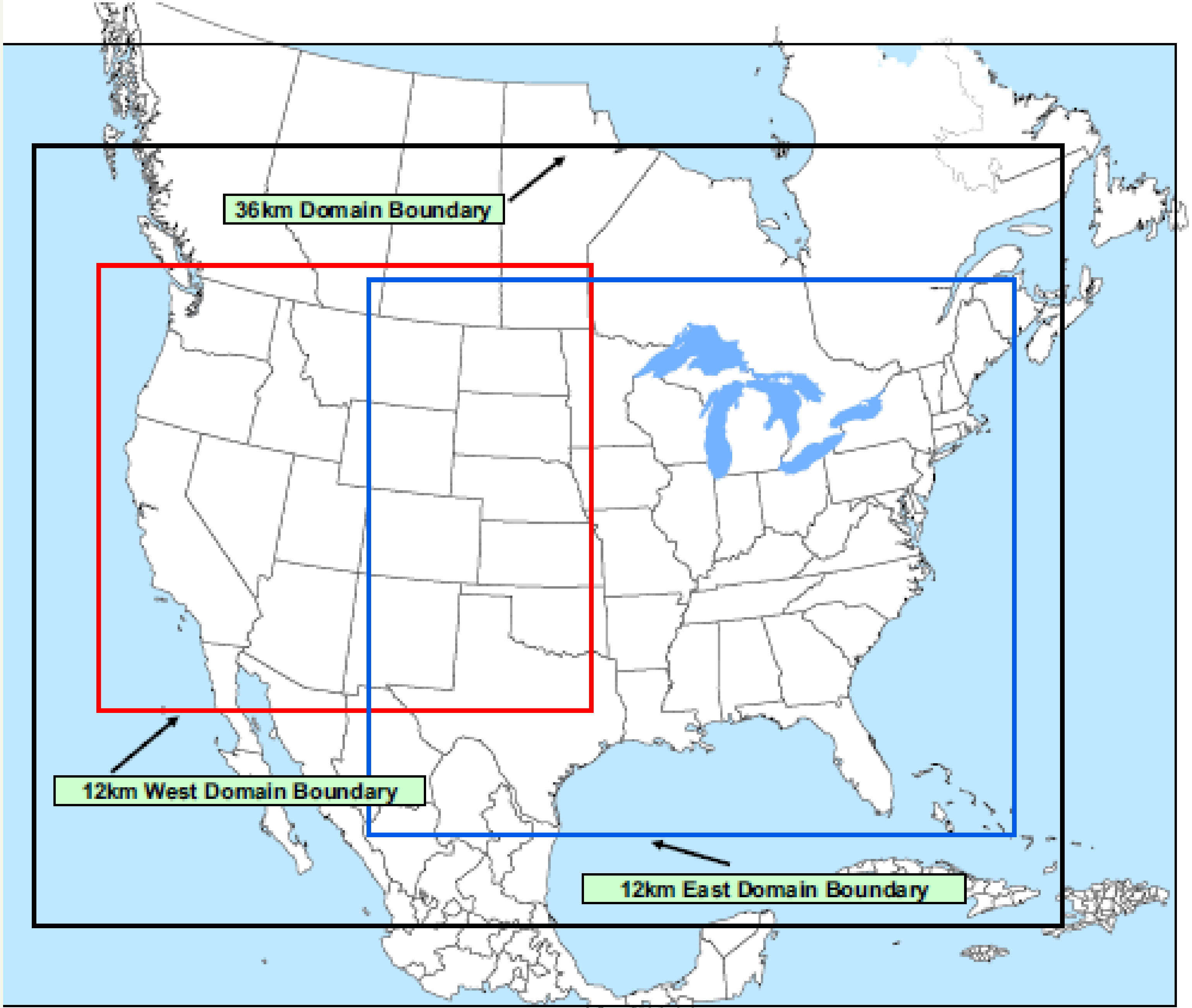
Connecticut 1-Hour, & 8-Hour (75 ppb) Ozone Exceedance Day Trends and Implemented Control Strategies 1975 - 2009



Ozone Modeling Approach

- **Define**:
  - geographic domain (E. U.S.)
  - photochemical grid model (CMAQ, 12 km grid)
  - meteorological model (WRF) embedded in hemispheric model
- **Prepare**:
  - base year emissions (2007)
  - hourly speciated emissions (SMOKE processor)
  - base year meteorology (2007 WRF model)
  - emissions grown and controlled to 2017 and 2020 (moderate and serious attainment dates)
- **Run**:
  - CMAQ and evaluate base year model performance
    (compare with 2007 monitored data)
  - CMAQ with future year emissions
    (calculate [gridded relative change] x [base year design values])
- **Compare**: CMAQ results vs. O3 NAAQS

Map of the CMAQ Modeling Domains Used for Ozone NAAQS



Collaborations Needed for Ozone Modeling

- CT, NY, NJ
  (multi-state n.a. area)
- NESCAUM states
- MARAMA states
- OTC
- MANE-VU
- EPA Regions 1, 2 and 3
- EPA OAQPS
- RPO's in MW and SE
- NACAA
- NOAA, DOE, DOT
- Other states/agencies

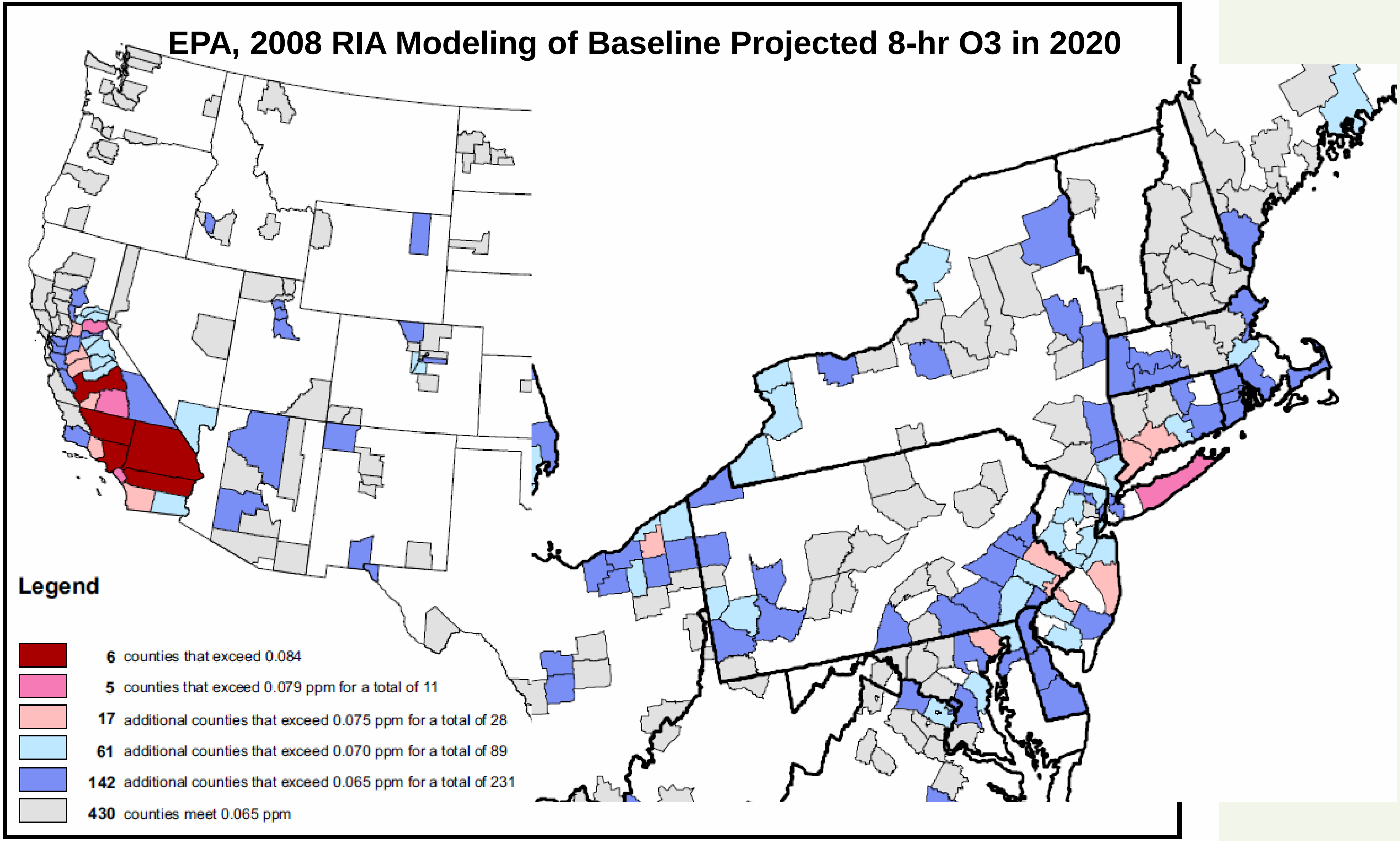
Examples of Recent Ozone Modeling by EPA and Northeast States

EPA

- CAIR (2005)
- O3 NAAQS (2008 RIA)
- *Transport rule (CAIR replacement , 2010)*
- *O3 NAAQS (2010)*

Northeast States

- Sensitivity modeling NYDEC (2006)
- Screening modeling NYDEC w support from OTR states (2010)
- SIP quality modeling (under development)



Modeled emissions reflect the expected reductions from federal programs including the Clean Air Interstate Rule (EPA, 2005b), the Clean Air Mercury Rule (EPA, 2005c), the Clean Air Visibility Rule (EPA, 2005d), the Clean Air Nonroad Diesel Rule (EPA, 2004), the Light-Duty Vehicle Tier 2 Rule (EPA, 1999), the Heavy Duty Diesel Rule (EPA, 2000), proposed rules for Locomotive and Marine Vessels (EPA, 2007a) and for Small Spark-Ignition Engines (EPA, 2007b), and state and local level mobile and stationary source controls identified for additional reductions in emissions for the purpose of attaining the current PM 2.5 and Ozone standards.

Modeled O3 Transport to CT: Excerpts from EPA CAIR Modeling, 2005

2010 Base Nonattainment Counties	2010 Base 8-Hour Ozone (ppb)	Percent of 8-Hour Ozone due to Transport
Fairfield CT	92	80 %
Middlesex CT	90	93 %
New Haven CT	91	95 %
Washington DC	85	38 %

Downwind Nonattainment Receptor		CAMX Source Apportionment Modeling Base Case: Total Number of Exceedances (grid-hours) = 65						CAMX State Zero-Out Modeling Base Case: Total Number of Exceedances (grids-days) = 10				
Fairfield CT	Upwind State	Average 3-episode % contribution	Highest daily average (ppb)	Highest daily average (%)	# reduced >= 2 ppb	% reduced >= 2 ppb	Max 8-hr ppb contribution	% total ppb reduced	% pop-wgt total ppb reduced	# reduced >= 2 ppb	% reduced >= 2 ppb	Max 8-hr ppb contribution
Contributions exceed screening criteria	PA	24	20	20	65	100	25	64	66	10	100	19.3
	NJ	21	18	18	65	100	23	42	37	10	100	14.1
	NY	19	17	19	65	100	23	-11	-19	4	40	8.4
	VA	5	6	7	62	95	6	8	9	4	40	6.4
	OH	9	8	8	65	100	10	16	15	9	90	6.3
	MD	4	7	8	56	86	7	8	8	3	30	4.1
	WV	3	3	3	62	95	3	9	9	5	50	2.5

Modeled O3 Transport CT to RI: Excerpts from EPA CAIR Modeling, 2005

Downwind Nonattainment Receptor	CAMX Source Apportionment Modeling Base Case: Total Number of Exceedances (grid-hours) = 134							CAMX State Zero-Out Modeling Base Case: Total Number of Exceedances (grids-days) = 18				
Kent RI	**Upwind State**	Average 3-episode % contribution	Highest daily average (ppb)	Highest daily average (%)	# reduced >= 2 ppb	% reduced >= 2 ppb	max 8-hr ppb contribution	% total ppb reduced	% pop-wgt total ppb reduced	# reduced >= 2 ppb	% reduced >= 2 ppb	max 8-hr ppb contribution
Contributions exceed screening criteria	**MA**	1	26	30	3	2	27	1	1	1	6	26.3
	NY	26	22	23	134	100	29	77	77	17	94	20.3
	PA	17	22	25	131	98	22	39	37	17	94	12.2
	NJ	16	14	17	131	98	18	45	41	17	94	9.8
	CT	10	8	9	125	93	15	29	35	17	94	9.7

Screening Runs (NYDEC, 2010)

Purpose

Investigate the level of emissions reductions needed to achieve the current NAAQS of 75 ppb and the potentially lower new NAAQS in the 60 to 70 ppb range across OTR

Design of the exercise

Perform screening simulations with existing data based on theoretical across-the-board reduction in emissions, as well as a simulation incorporating OTC-recommended national and local measures

Modeling Approach

- **Meteorology**: 2007 replicated by WRF (UMD)
- **Anthropogenic emissions**, 2007 Proxy, (NYDEC):
  - Actual 2007 for point and non-road sources within MANE-VU
  - Other point sources from EPA CHIEF 2005 Platform
  - Remaining source sector emissions were interpolated from 2002 and 2009 inventories from 2002 SIP platform
- **Biogenic emissions**, 2007: based on MEGAN (NYDEC)
- **Photochemical model** – CMAQ with CB5 chemistry (NYDEC)
- **Modeling domain**: 12 km Eastern U.S.
- **Boundary conditions** always kept at “clean” background levels

2007 Proxy Inventory Development

2007 Proxy Emission Inventories					
	MANEVU	VISTAS	MRPO	CENRAP	CANADA
Area	Interpolated 2007	Interpolated 2007	Interpolated 2007	Interpolated 2007	OME 2005
MAR	Interpolated 2007	Interpolated 2007	Interpolated 2007	Interpolated 2007	OME 2005
Nonroad	MACTEC/ALPINE 2007	Interpolated 2007	Interpolated 2007	2002 SIP Platform	OME 2005
C3MV (Cat 3 Marine Vessels)	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform
Non EGU Point	MACTEC/ALPINE 2007	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	OME 2005
EGU Point	MACTEC/ALPINE 2007	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	OME 2005
Mobile	Interpolated 2007 activity data and existing MOBILE6 inputs with county level MOBILE to MOVES adjustment factors from EPA	Interpolated 2007 activity data and existing MOBILE6 inputs with county level MOBILE to MOVES adjustment factors from EPA	Interpolated 2007 activity data and existing MOBILE6 inputs with county level MOBILE to MOVES adjustment factors from EPA	Interpolated 2007 activity data and existing MOBILE6 inputs with county level MOBILE to MOVES adjustment factors from EPA	OME 2005 (Canadian MOBILE6 Activity and Input Data)
Biogenic	MEGAN	MEGAN	MEGAN	MEGAN	MEGAN
Anthropogenic Chlorine	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	N/A
Oceanic Chlorine	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform	EPA CHIEF 2005 Platform

Interpolated 2007 - Emissions data for 2007 developed by interpolating between 2002 and 2009 inventories from 2002 SIP platform.

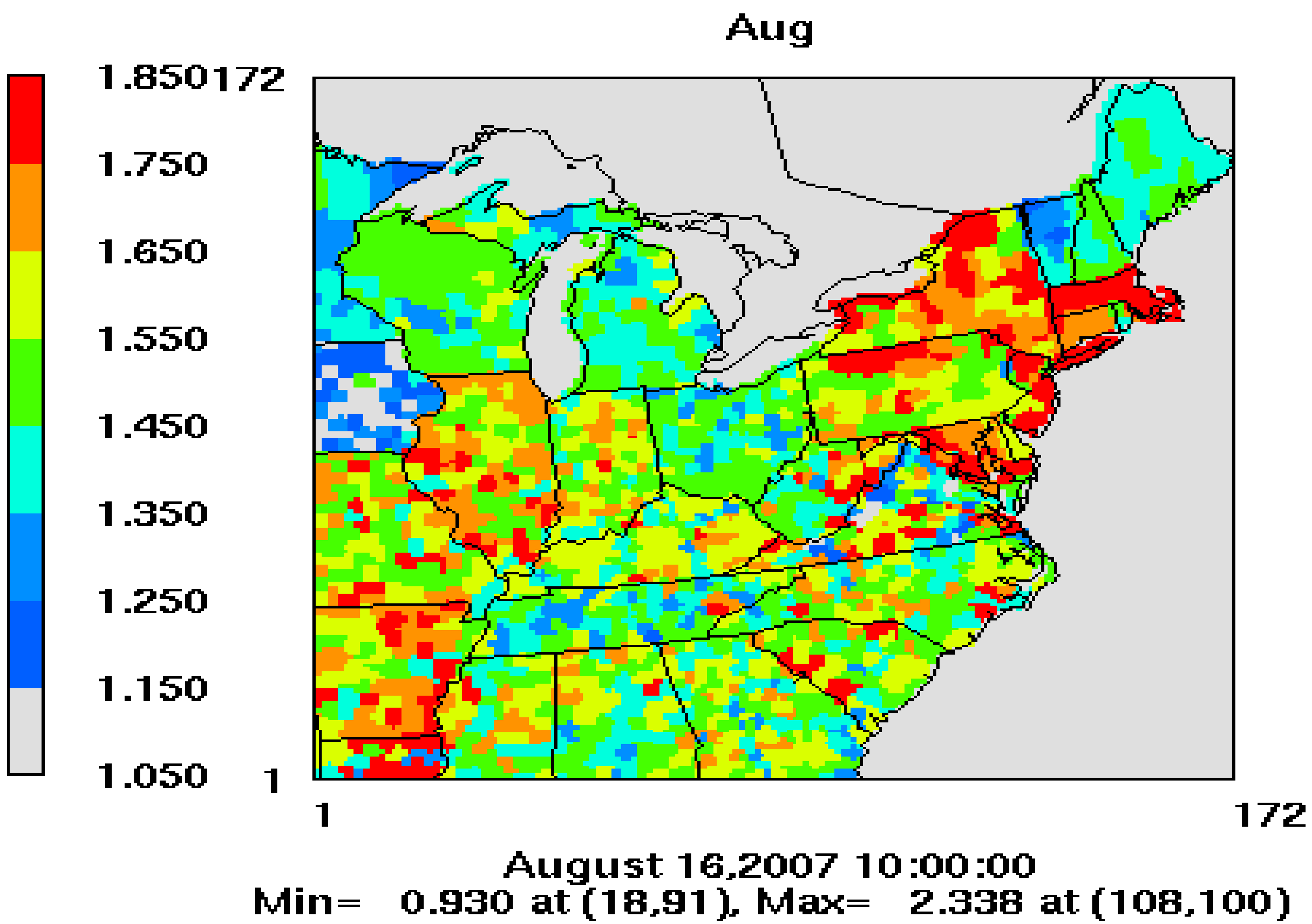
MACTEC/ALPINE 2007 - Contractor developed 2007 SIP inventories available at the time of screening modeling.

OME 2005 - The latest available inventories for Canada from the Ontario Ministry of the Environment.

EPA CHIEF 2005 Platform - Used for point sources . Difficult to interpolate as Emission Units frequently change and no regionally consistent definition of EGU/Non-EGU sources. Also used for Chlorine and C3MV.

2002 SIP Platform - 2009 CENRAP Nonroad inventory incomplete therefore the 2002 nonroad inventory was used.

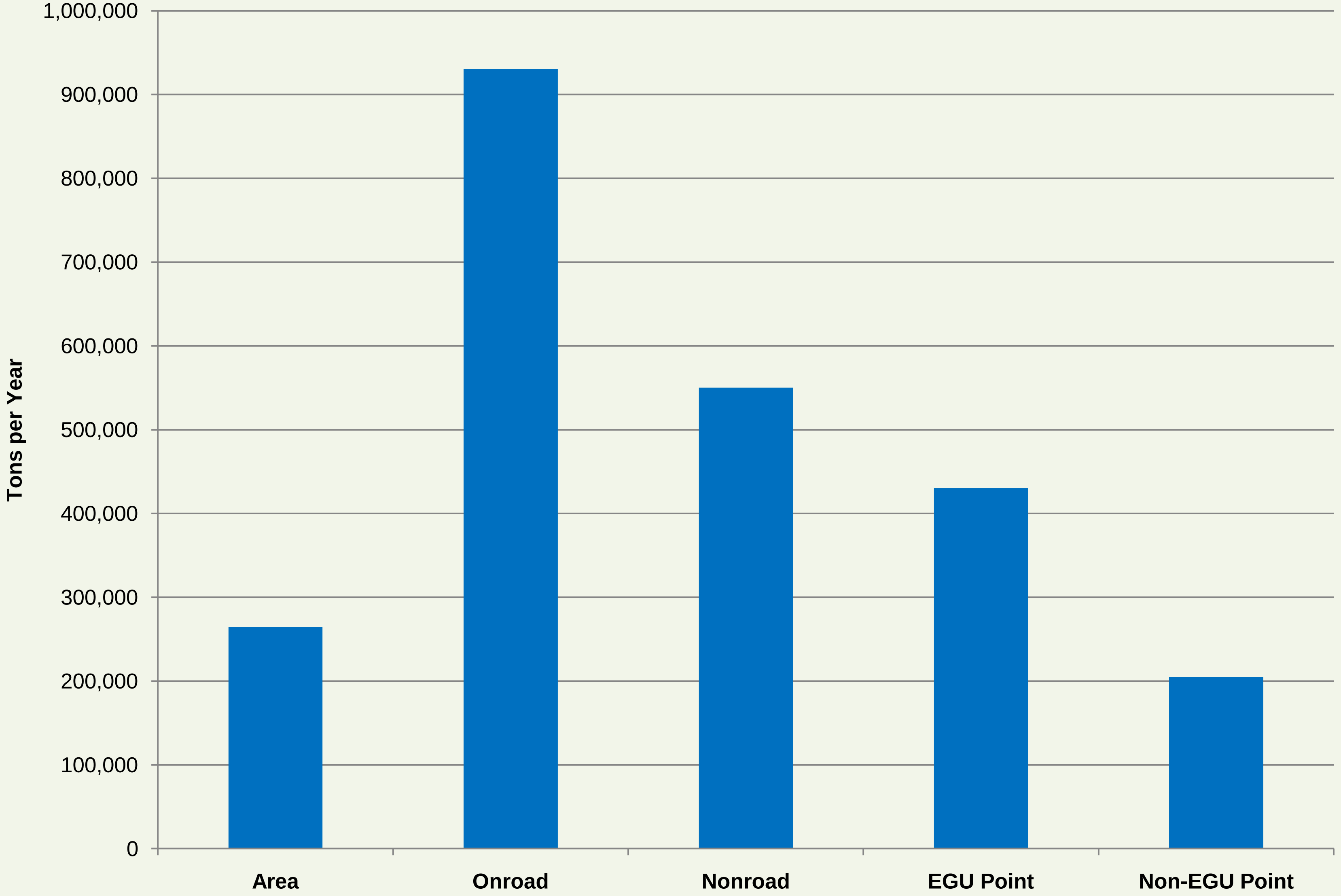
NOX MOVES/NMIM Ratio

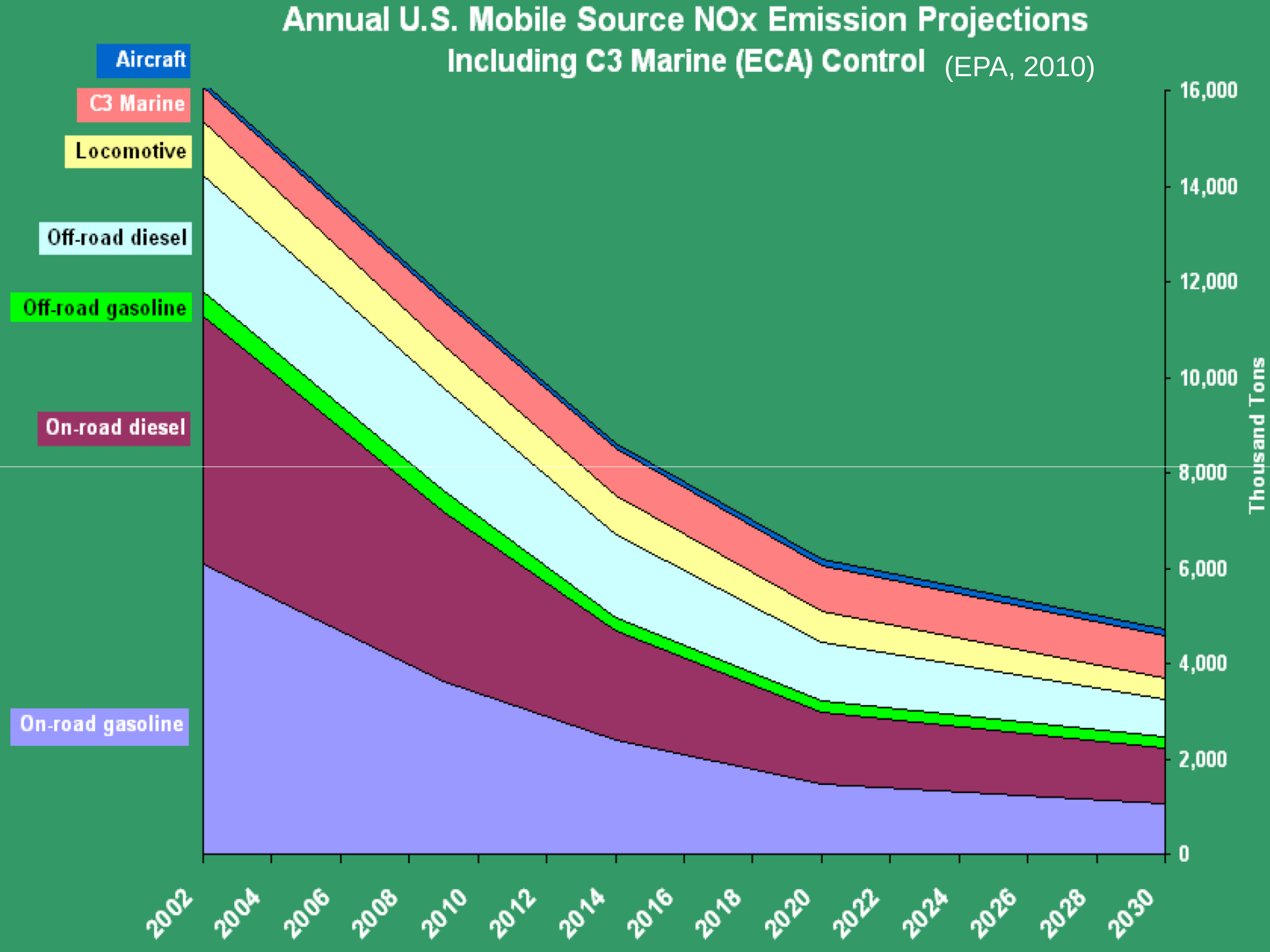


MOVES emissions are 60-80 % higher than NMIM(Mobile-6)

MOVES emissions based on EPA provided data to approximate MOVES model output

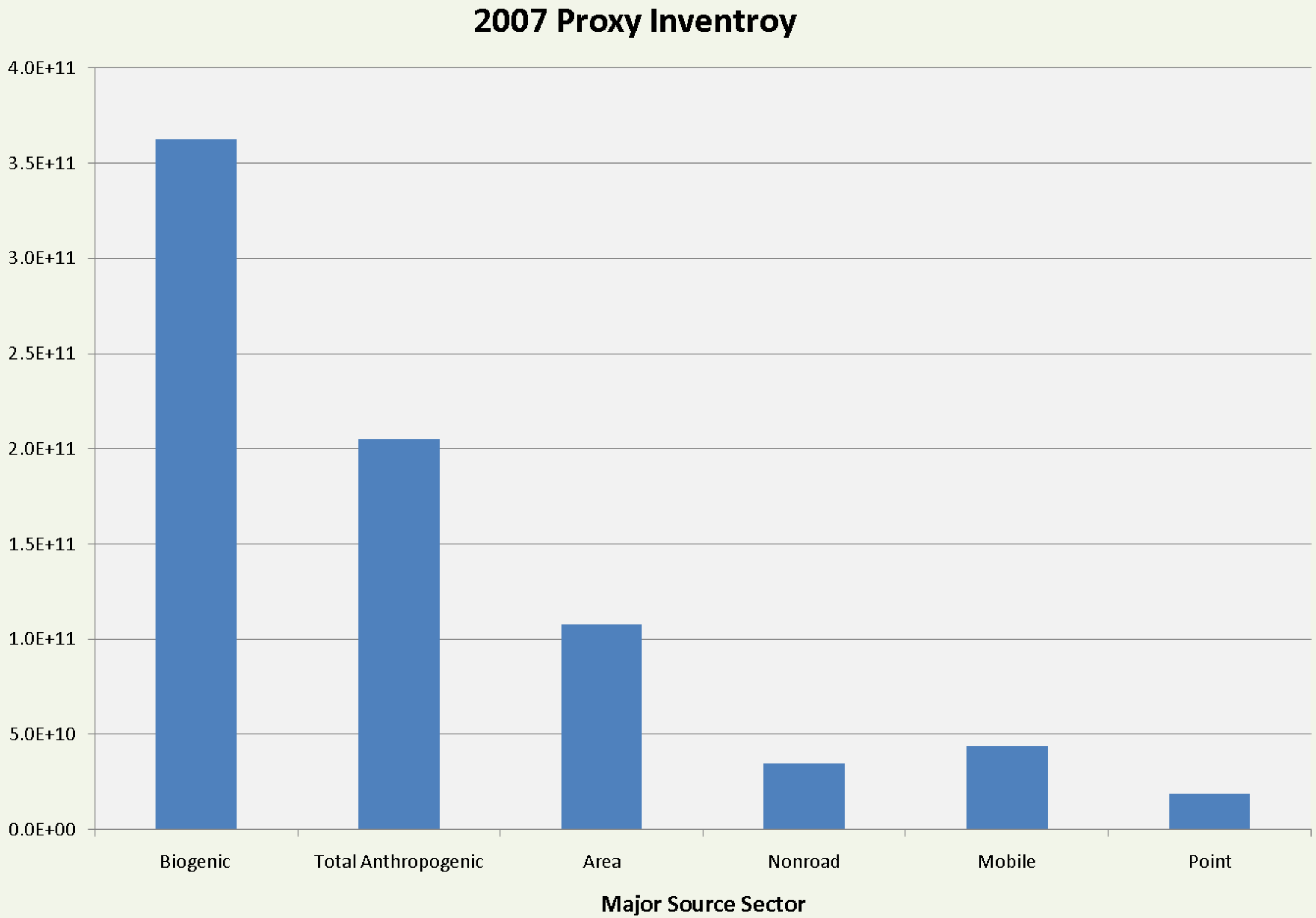
NOx Emissions 2007
Proxy Inventory, MANE-VU





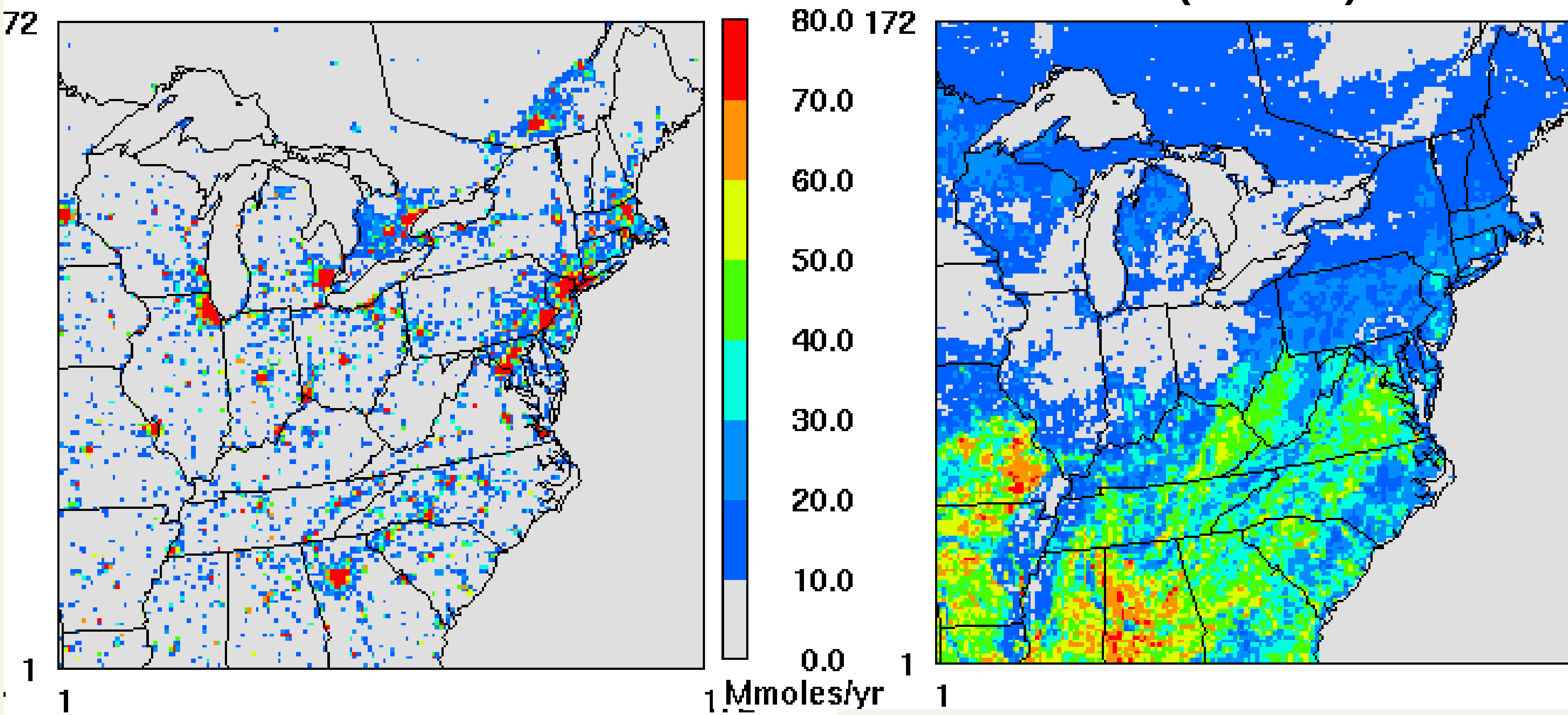
Annual U.S. Mobile Source NOx Emission Projections
Including C3 Marine (ECA) Control
(EPA, 2010)
Aircraft
C3 Marine
Locomotive
Off-road diesel
Off-road gasoline
On-road diesel
On-road gasoline
Thousand Tons
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030

Domain-Wide VOC Emissions



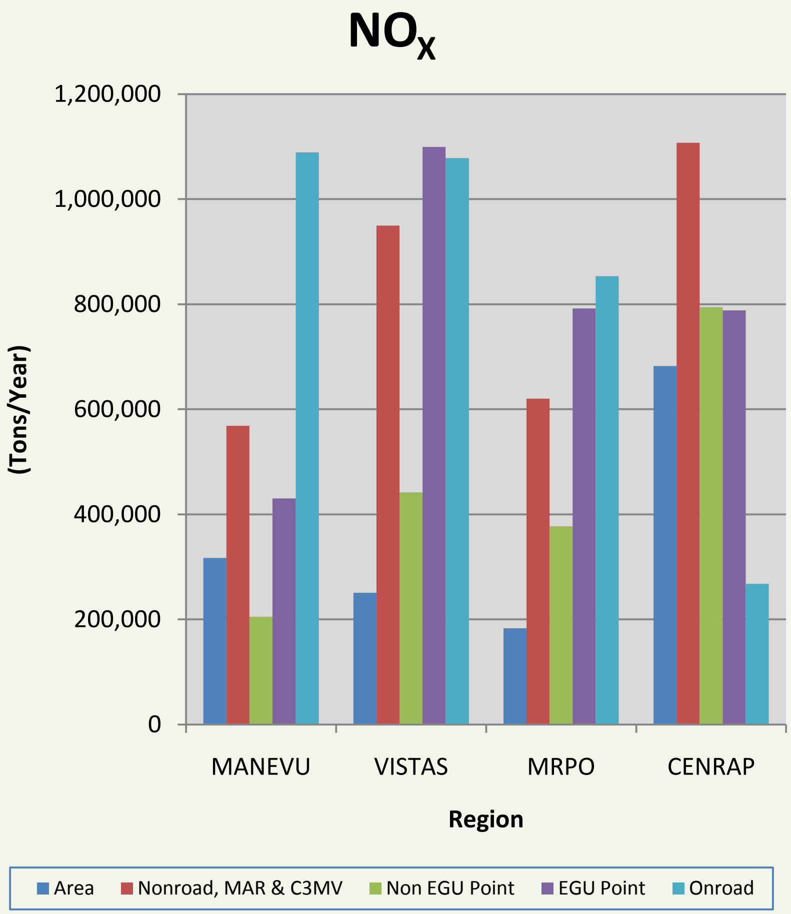
Distribution of Domain VOC Emissions

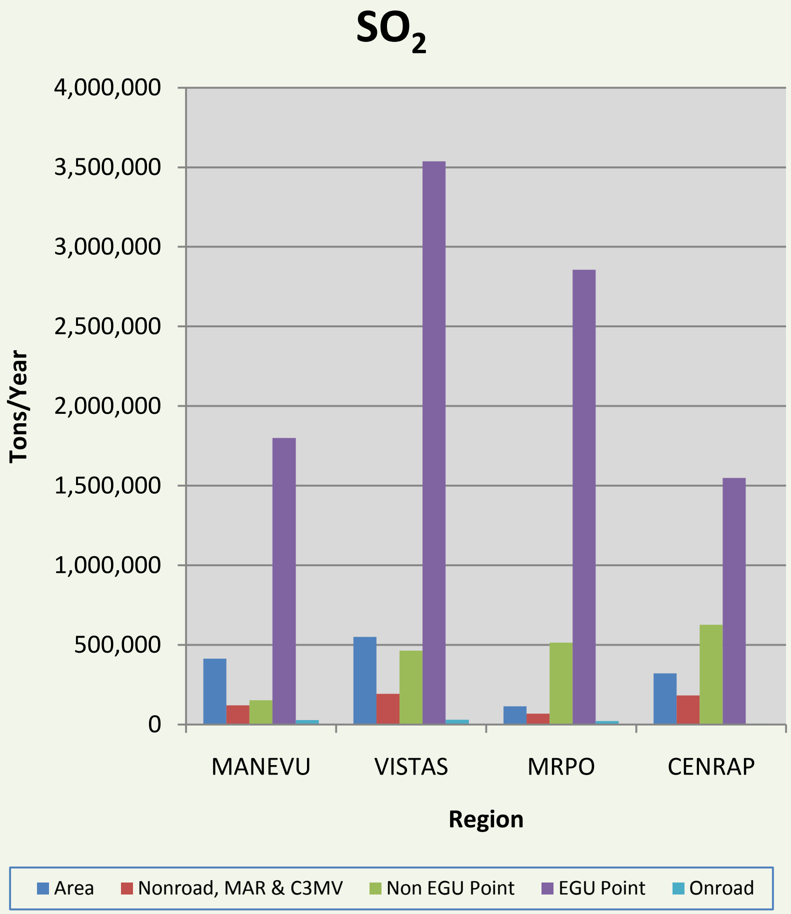
Man-Made VOC Emissions | **Natural VOC Emissions (MEGAN)**



- **Man-made VOC emissions are dominant in urban areas**
- **Natural VOC emissions are dominant in forested areas, especially in the south**

2007 Proxy Inventory Emissions

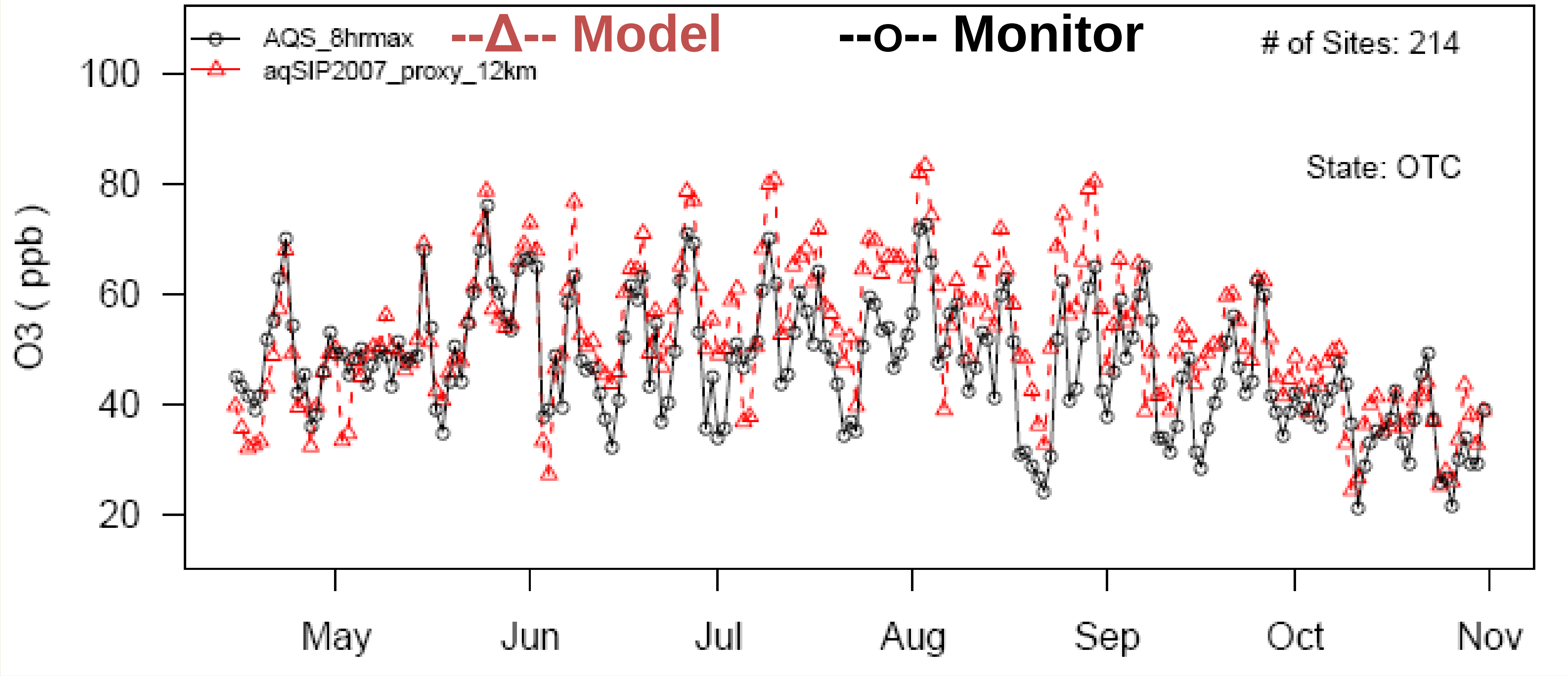




Model Performance

Time Series Comparison of Model vs. Monitored 8-hr Ozone

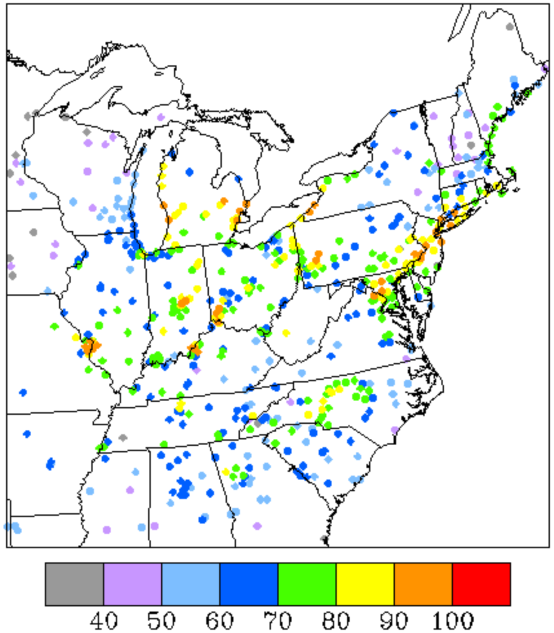
(April 15 – October 30, 2007)

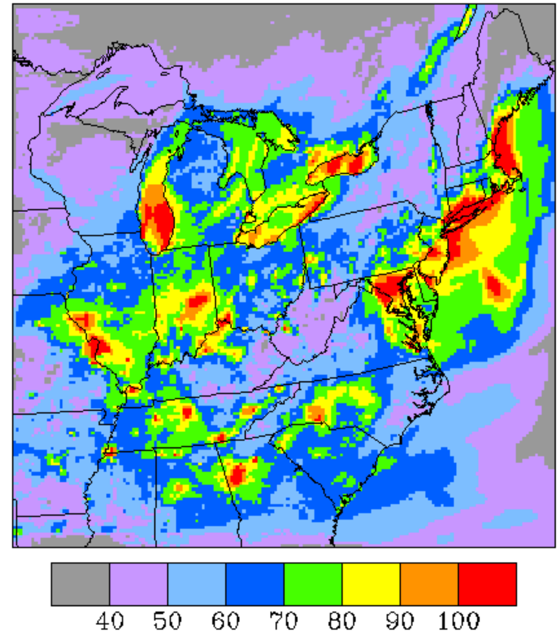


- The timing of episodes is generally captured, but their magnitude tends to be overestimated

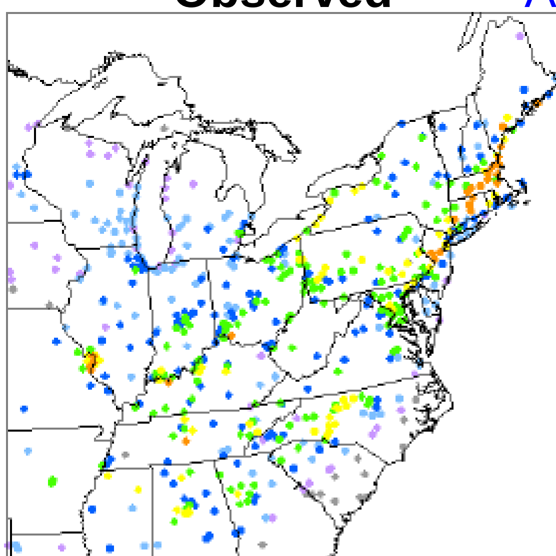
Model Performance is Acceptable!

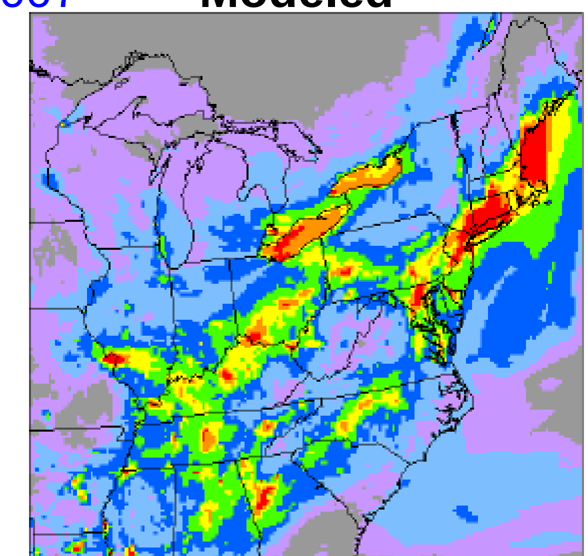
Observed August 2, 2007 **Modeled**





Observed August 3, 2007 **Modeled**





Screening Simulations

Two of the simulations are theoretical across-the board emission reductions of all man-made sectors throughout domain:

Screening simulation 1:

50% NOx and 30% VOC reductions

Screening simulation 2 (results coming shortly):

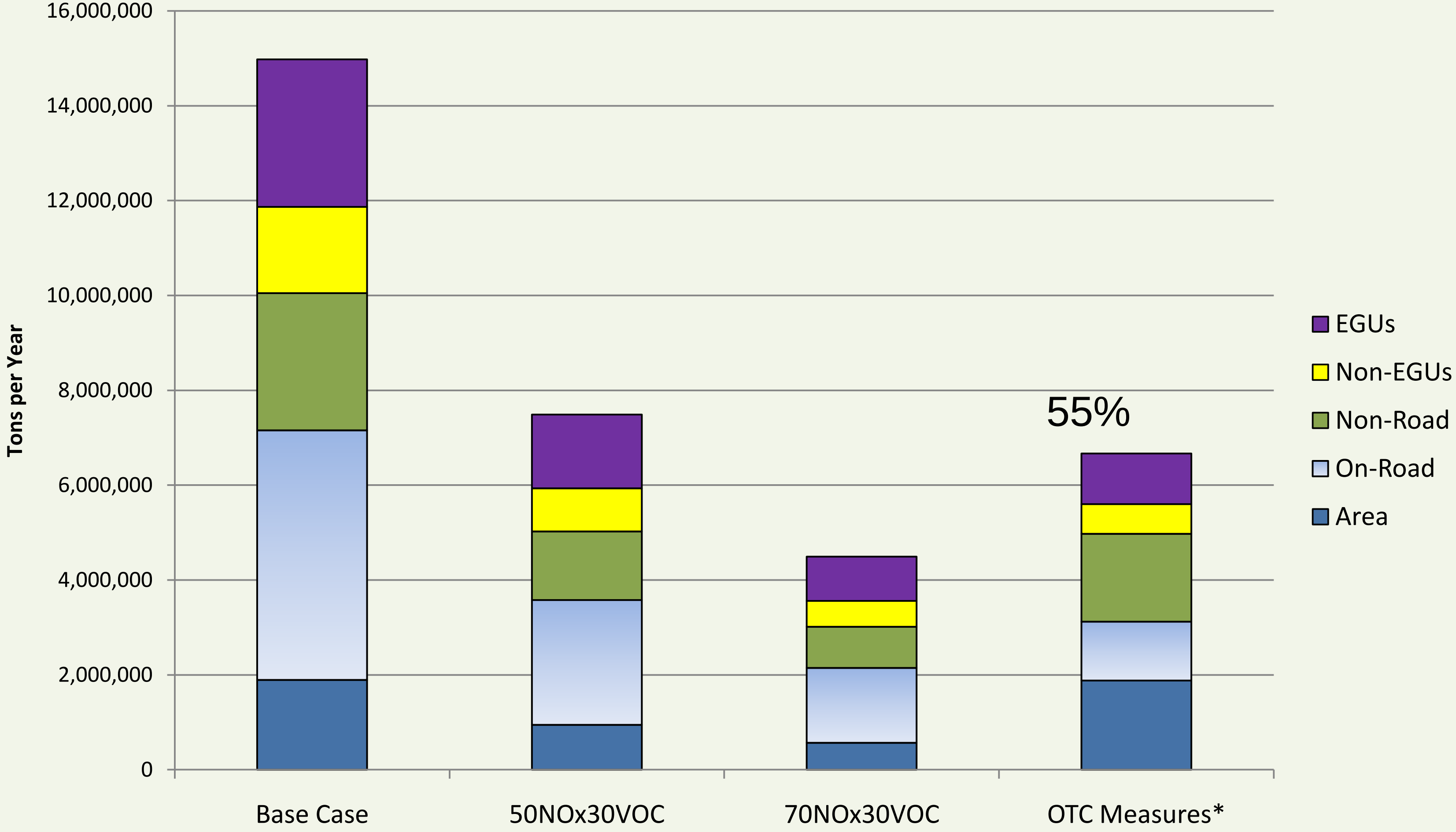
70% NOx and 30% VOC reductions

Third Screening Simulation (to be completed):

Intended to illustrate OTC's recommendation for critical national reductions combined with local OTR measures

- VOC Domain-wide
  - All anthropogenic sectors: -30% across entire modeling domain
- NOx Domain-wide
  - Point: -65% (includes reductions from ICI boilers and cement kilns and a 900,000 ton regional trading cap on EGUs)
  - On-road: -75% (includes reductions from LEV 3)
  - Non-road: -35% (includes reductions from marine and locomotive engines)
- NOx in OTR States
  - Additional -5% across all sectors in the OTR

Comparing NOx Reductions in Screening Runs: MOVES Adjustment



- All screening runs reduce VOC emissions by 30%.
- *OTC National Recommendation approximates an overall 55% NOx reduction

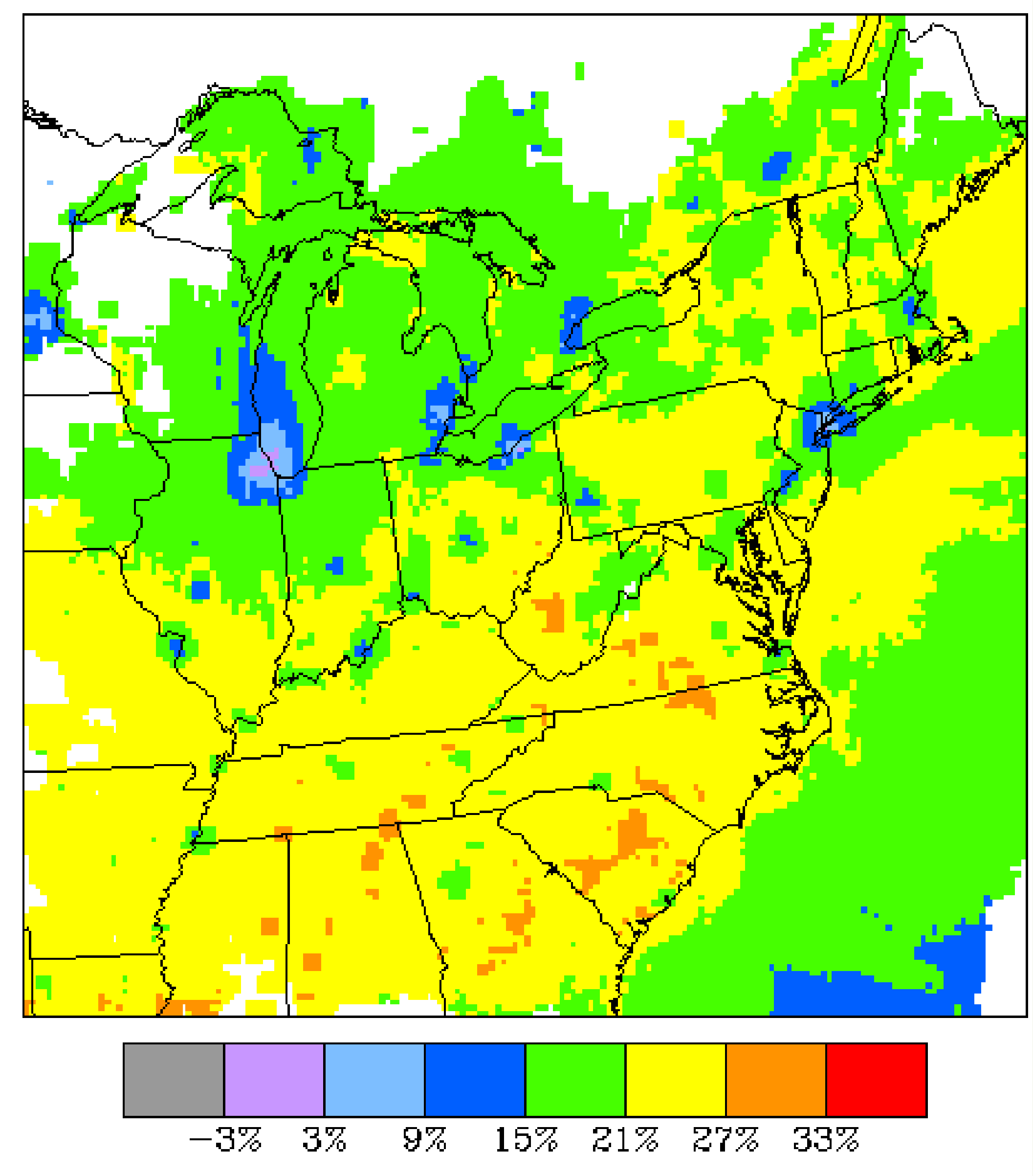
Results

Caveats

- These screening runs use proxy emissions through interpolated inventories for many sectors and regions
- Un-tested and un-refined “MOVES-like” adjustment to MOBILE6 emissions
- Use of “time invariant clean” boundary conditions
- Screening simulations based on across-the-board emissions reductions

  - This is not SIP Quality modeling!!

Relative Ozone Reductions
Due to 50% NOx and 30% VOC Reductions

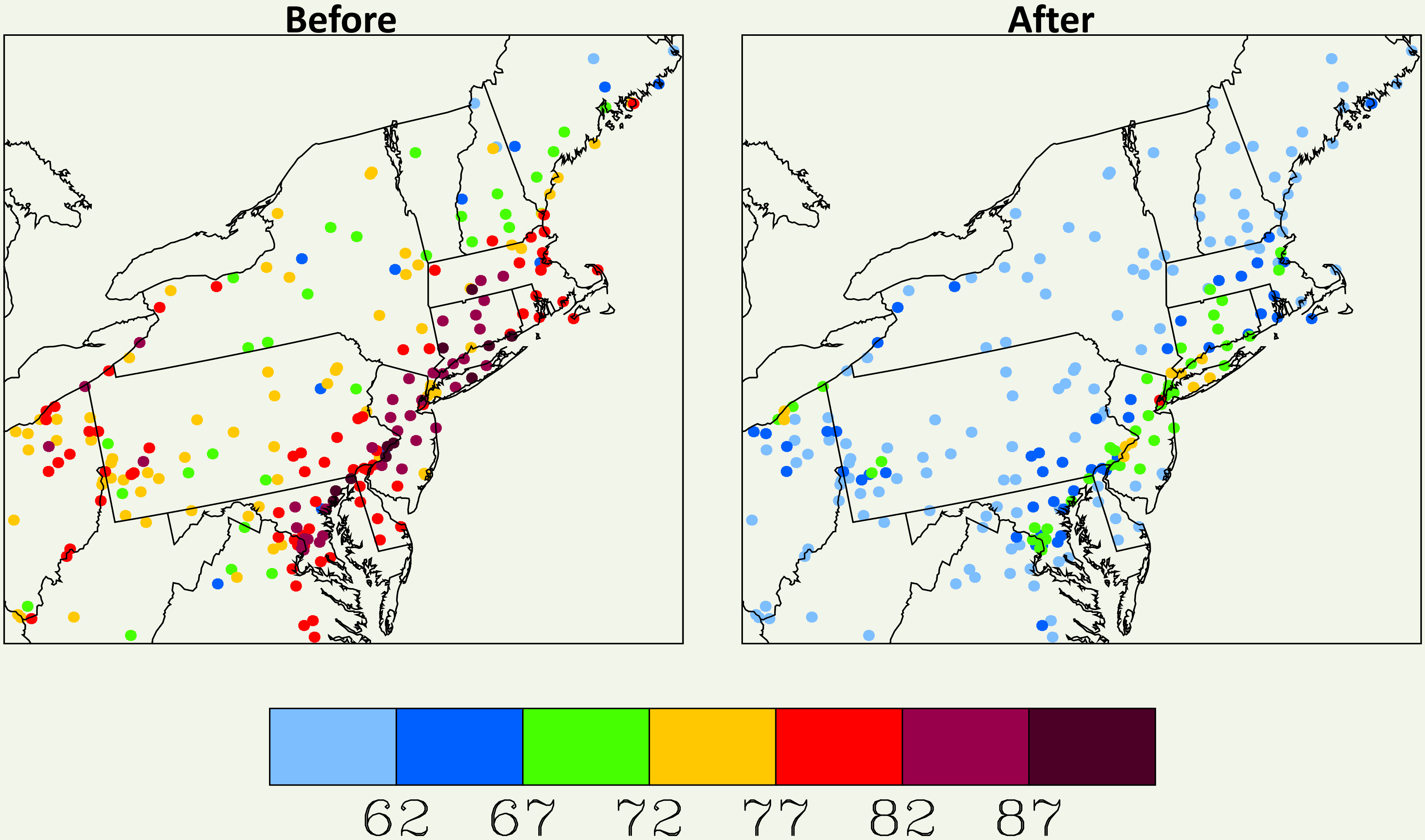


NO_x- focused emission reductions show less benefit for urban core areas

Model Predicted Ozone Concentration Design Values

With 50% NOx and 30% VOC Reductions Across-the-Board

(Hot Spots remain in Urban Areas)



Next Steps

- Northeast Regional Modeling (OTC)
  - Screening modeling (summer 2010)
  - SIP Quality Modeling (2011-2013)
- EPA Transport Rule Modeling (June 2010)
- EPA Reconsidered Ozone NAAQS Modeling

These modeling studies will be used to help inform CTDEP whether transport will be adequately reduced:

1. from upwind states to nonattainment in CT, and
2. from CT to nonattainment in downwind states.