Air Quality Screening Modeling

Emissions and Photochemical Modeling

OTC Modeling Committee Meeting

September 16, 2010

Baltimore, MD

OZONE TRANSPORT COMMISSION

Screening Runs

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

Design of the exercise

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

Modeling Approach

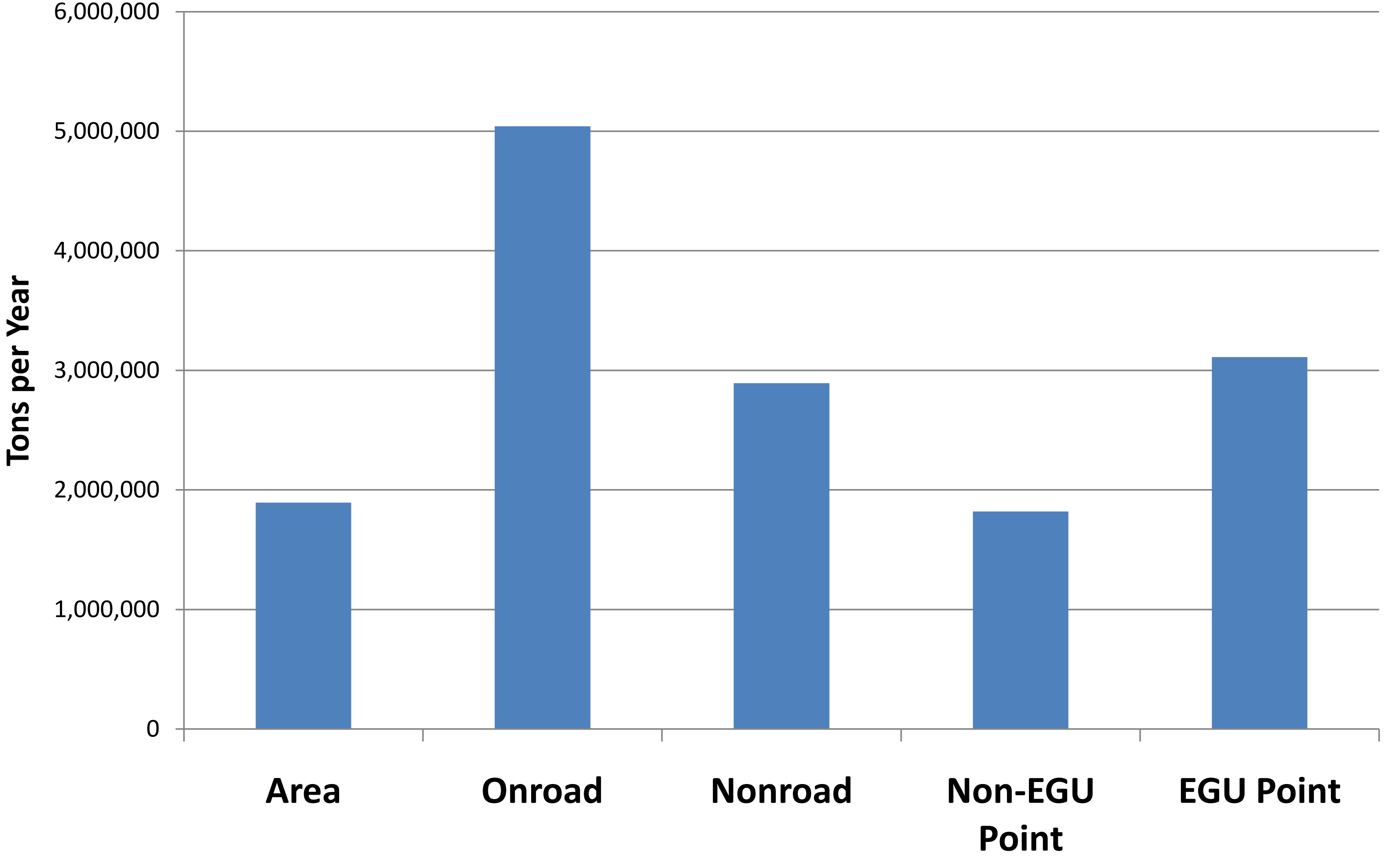
- 2007 Meteorology replicated by WRF
- Man-made Proxy Emissions:
  - Actual 2007 for point and non-road sources within MANE-VU
  - Other point sources from EPA CHIEF 2005 Platform
  - Remaining source sector emissions were interpolated from 2002 and 2009 inventories from 2002 SIP platform
- 2007 Natural emissions based on MEGAN
- Photochemical model – CMAQv4.7 with CB5 chemistry
- Modeling domain: 12 km Eastern U.S.
- Boundary conditions always kept at “clean” background levels
- Modeling period: April 1 – October 31 for base case

Participants in this Effort

- NJDEP/ORC
- UMD/MDE
- NYSDEC
- MARAMA
- OTC

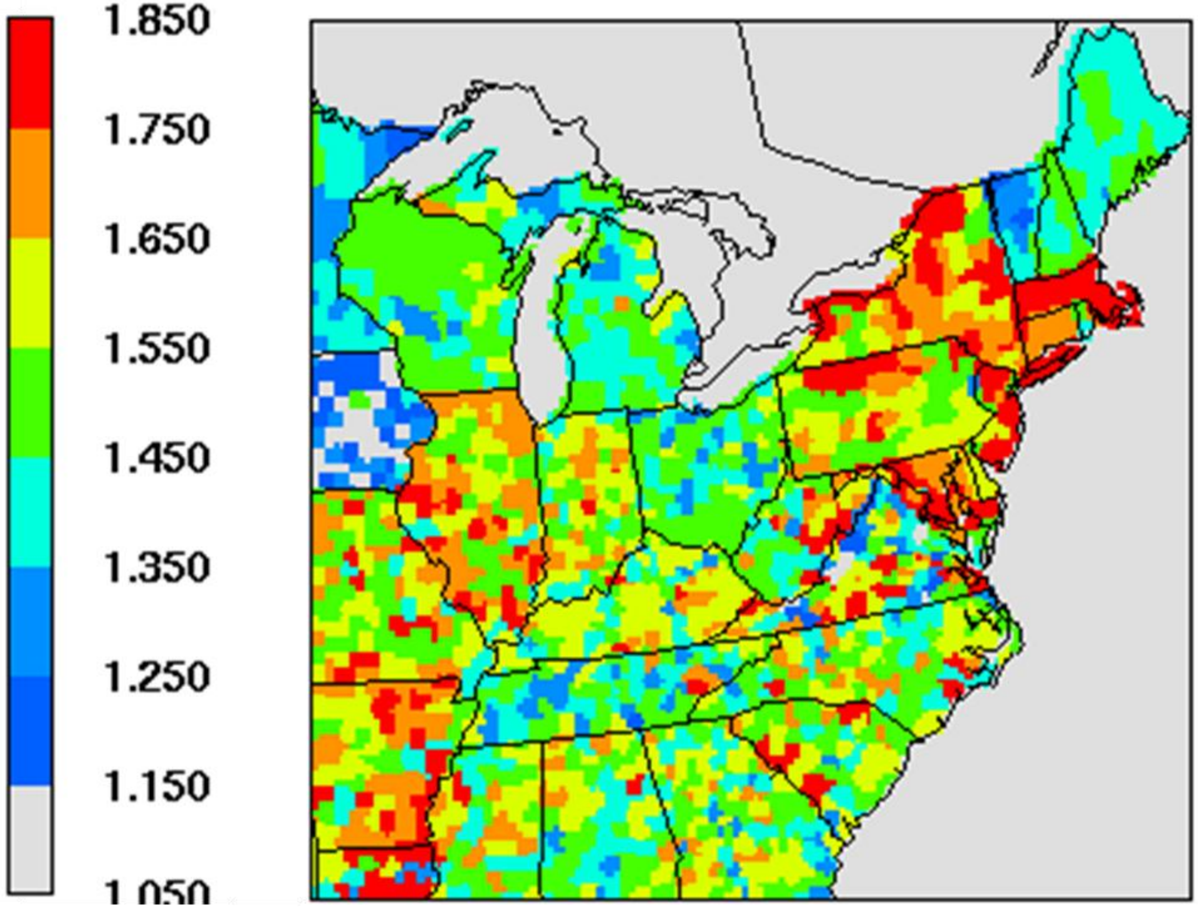
Domain-wide NOx Emissions*

2007 Proxy Inventory



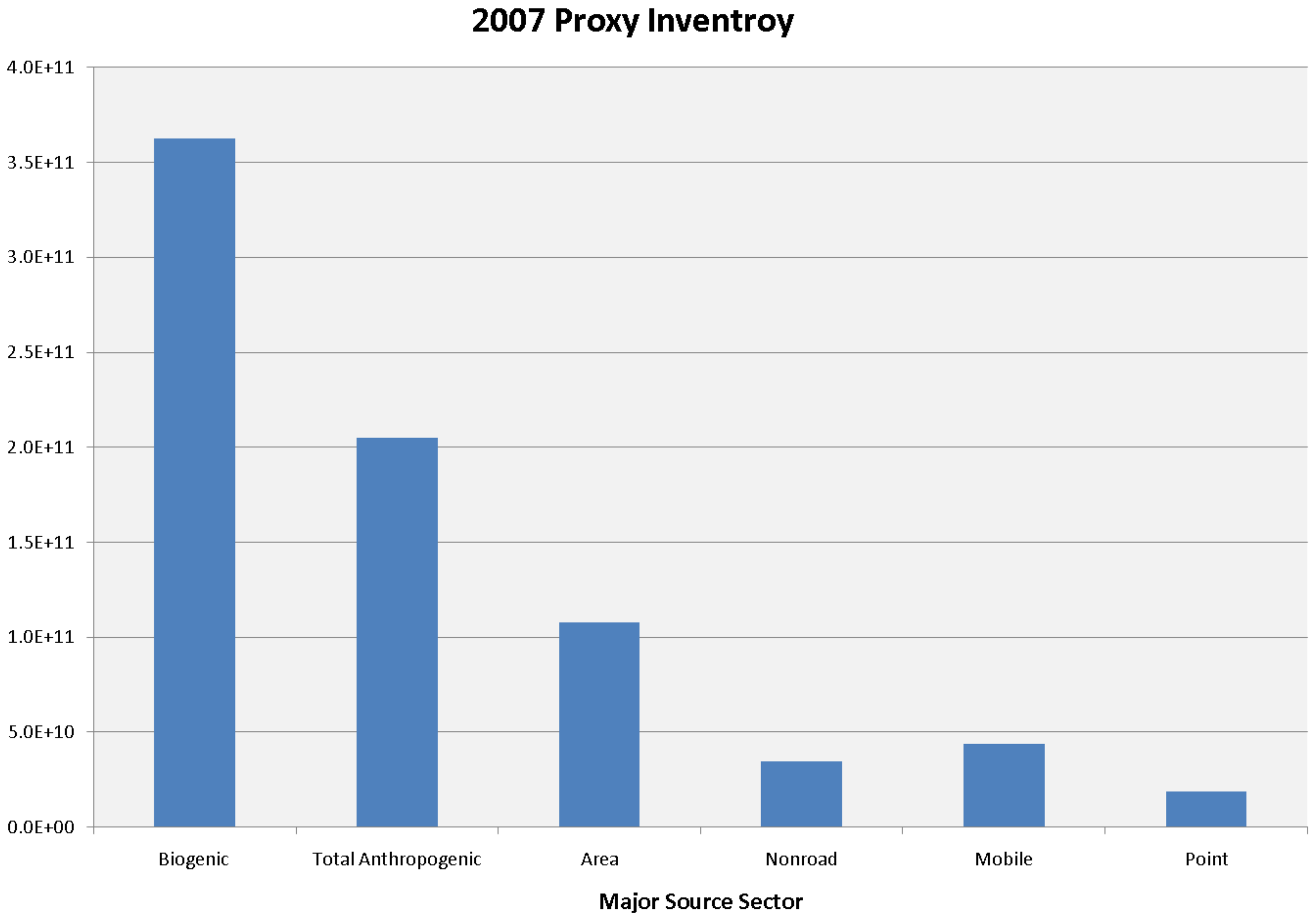
*Includes MOVES adjustments to MOBILE6 emissions

NOx MOVES/NOx Mobile 6 Ratio (August)



- MOVES emissions are 60-80 % higher than Mobile-6
- MOVES emissions based on EPA provided data to approximate MOVES model output

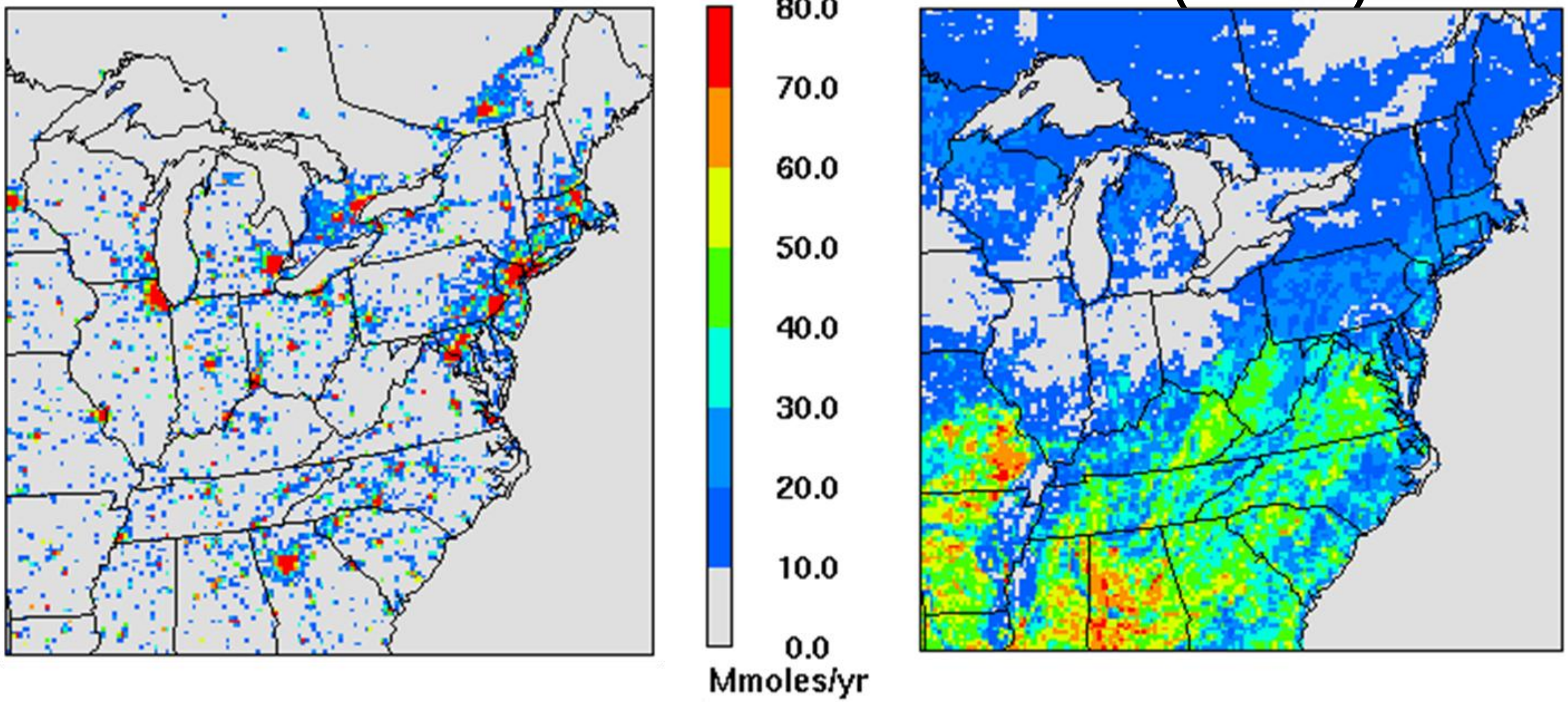
Domain-Wide VOC Emissions



Distribution of Domain VOC Emissions

Man-Made VOC Emissions

Natural VOC Emissions (MEGAN)

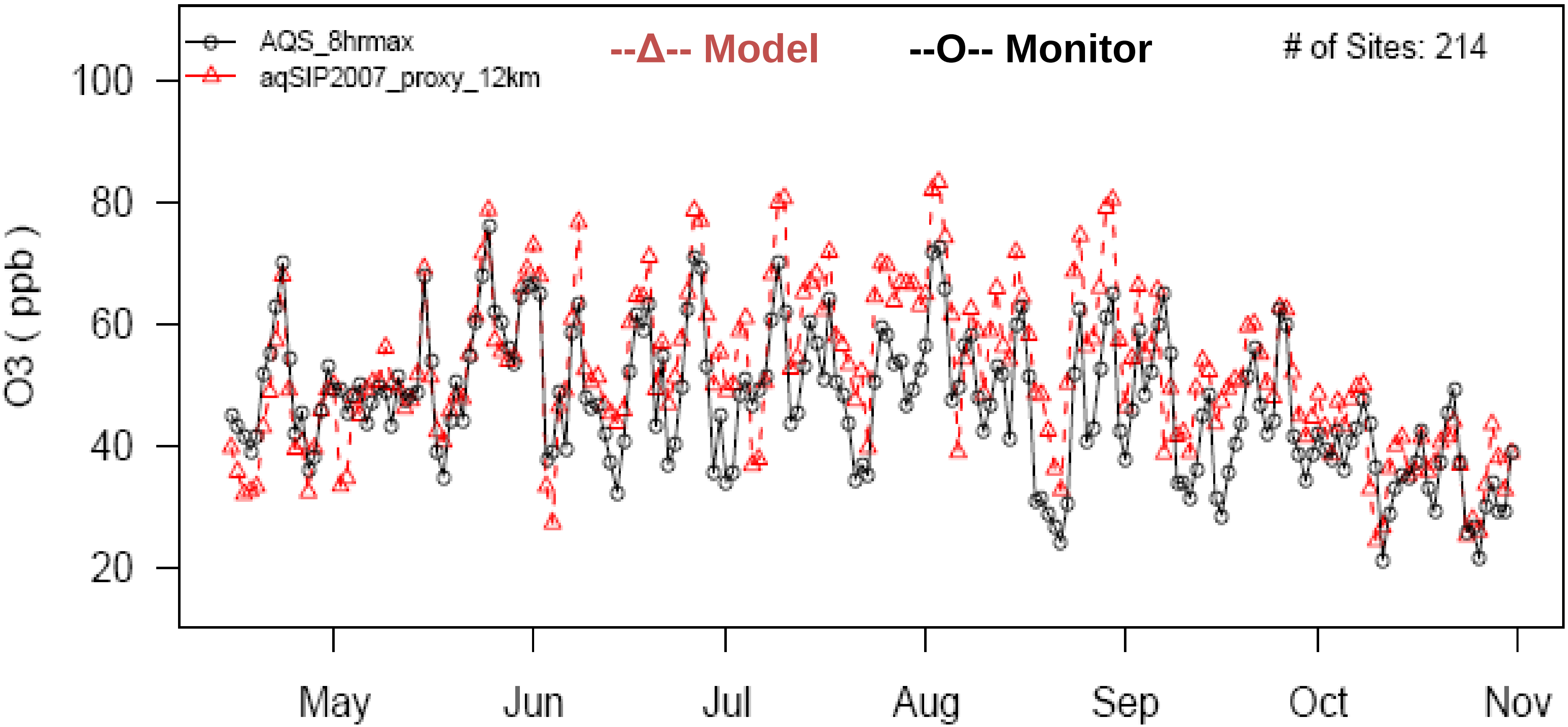


- Man-made VOC emissions are dominant in urban areas
- Natural VOC emissions are dominant in forested areas, especially in the south

Model Performance

Time Series Comparison

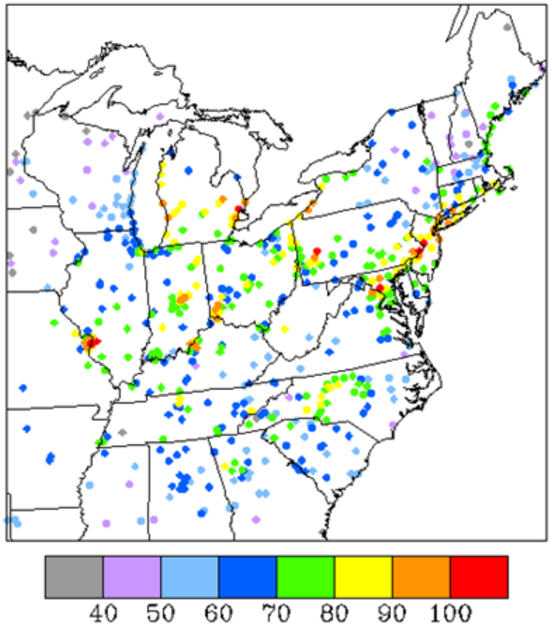
Model vs. Monitored 8-hour Ozone, OTC States

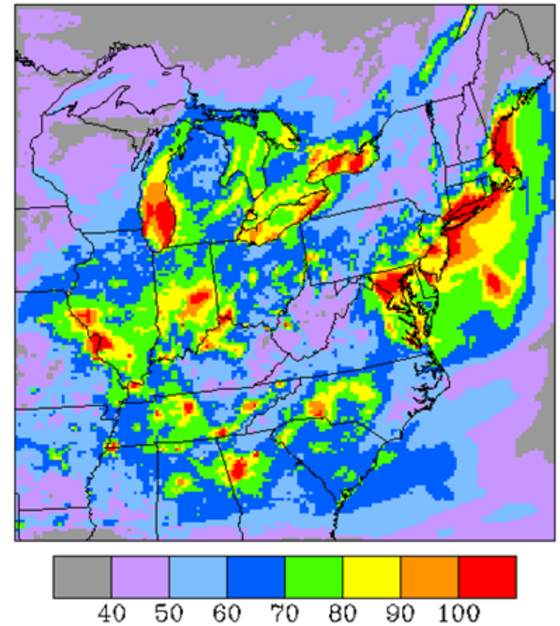


- The timing of episodes is generally captured, but their magnitude tends to be overestimated

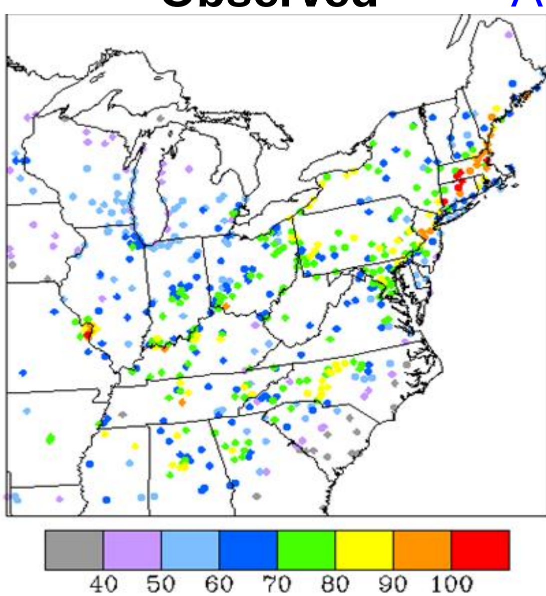
Model Performance During Ozone Episode

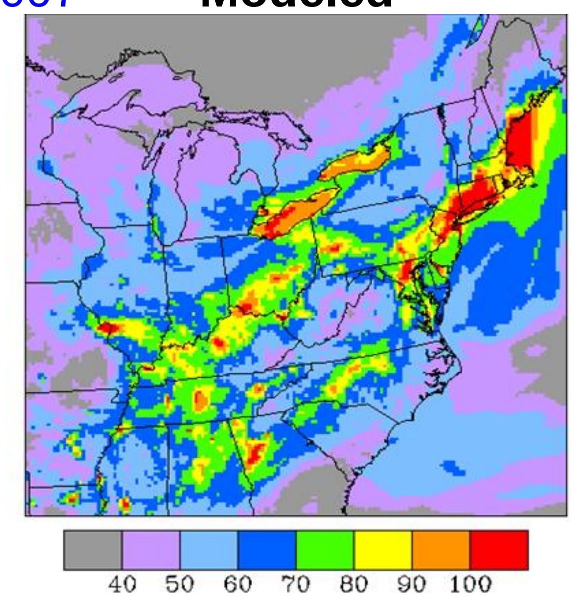
Observed August 2, 2007 **Modeled**





Observed August 3, 2007 **Modeled**





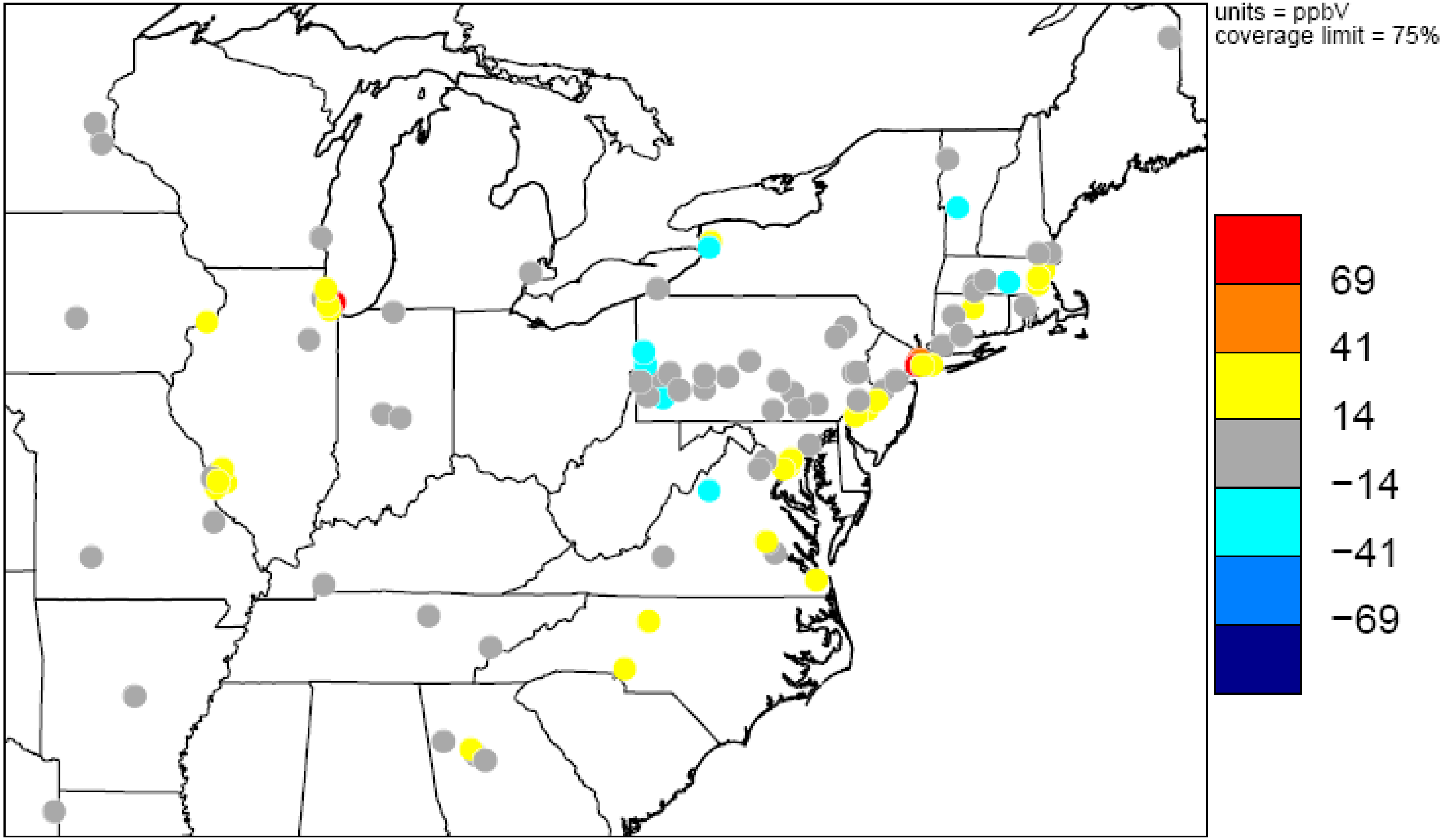
Summary Model Performance Statistics for Daily Maximum 8-hour Ozone

Region	Data Pairs	Mean Observed	Mean Model	Mean Bias (ppb)	Mean Error (ppb)	Normalized Mean Bias (Percent)	Normalized Mean Error (Percent)	Root Mean Square Error (ppb)	Correlation Coefficient
Domain-wide	115,712	49.7	51.9	2.2	9.5	4.4	19.2	12.4	0.7
OTC States	39,320	47.6	52.7	5.0	10.3	10.6	21.5	13.4	0.73

- Model performance is within the range of previous studies

Mean Bias of 6am-9am Average NOx Concentrations

Model minus Observed



Screening Simulations

Two theoretical simulations with across-the board reductions on all man-made sectors throughout domain:

Screening simulation 1:

50% NOx and 30% VOC reductions ("N50V30")

Screening simulation 2:

70% NOx and 30% VOC reductions ("N70V30")

These simulations were performed for April 1 – October 31, 2007

Screening Simulations (continued)

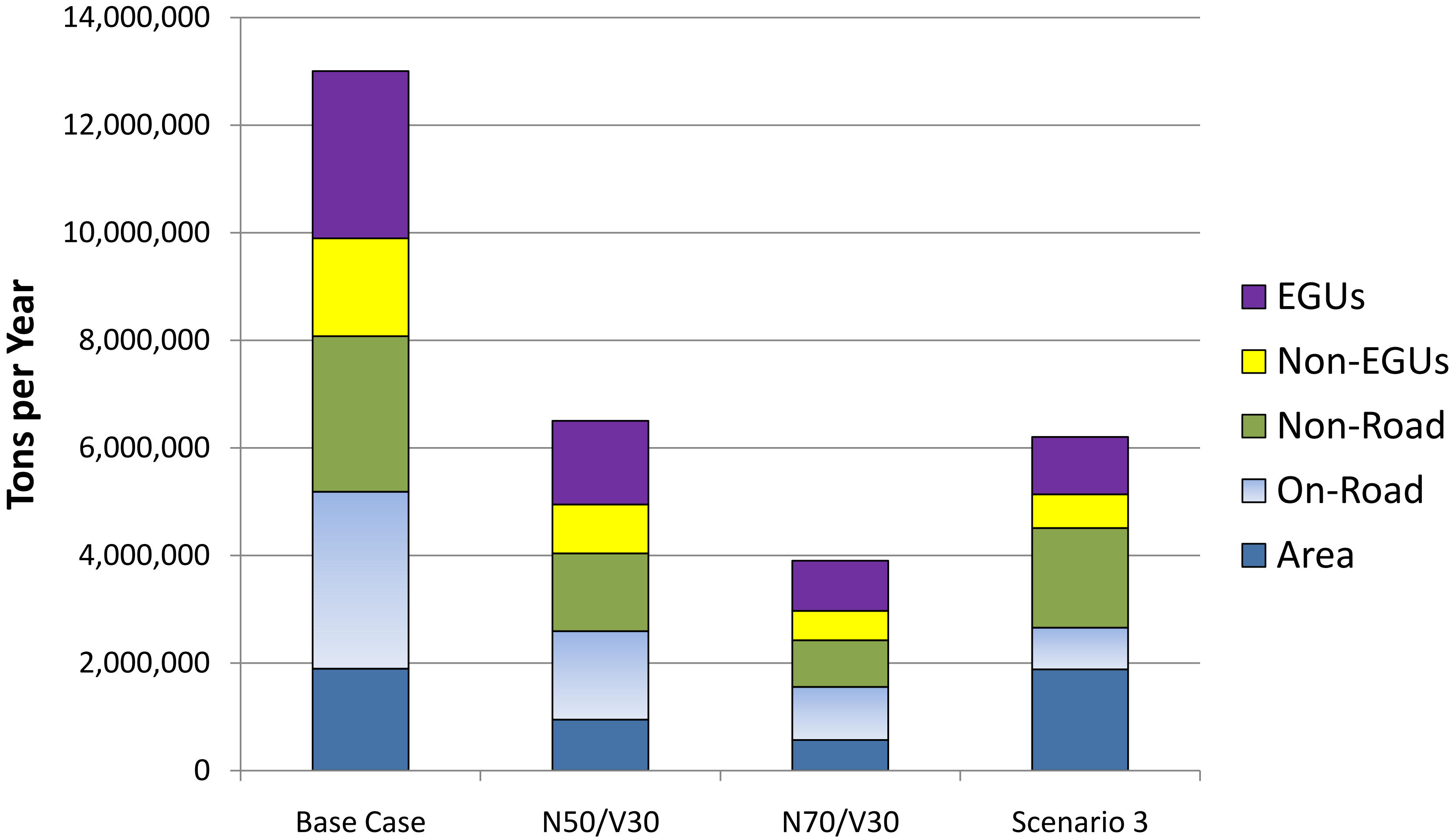
Screening simulation 3:

Approximates OTC's recommendation for critical national reductions combined with local OTR measures

- VOC: 30% reduction for all sectors across entire modeling domain
- NOx Domain-wide:
  - Point: 65% reduction (includes reductions from ICI boilers and cement kilns and a 900,000 ton regional trading cap on EGUs)
  - On-road: 75% reduction (approximates a 2020 national LEV 3)
  - Non-road: 35% reduction (includes reductions from marine and locomotive engines)
- NOx in OTR States:
  - Additional 5% reduction across all sectors in the OTR

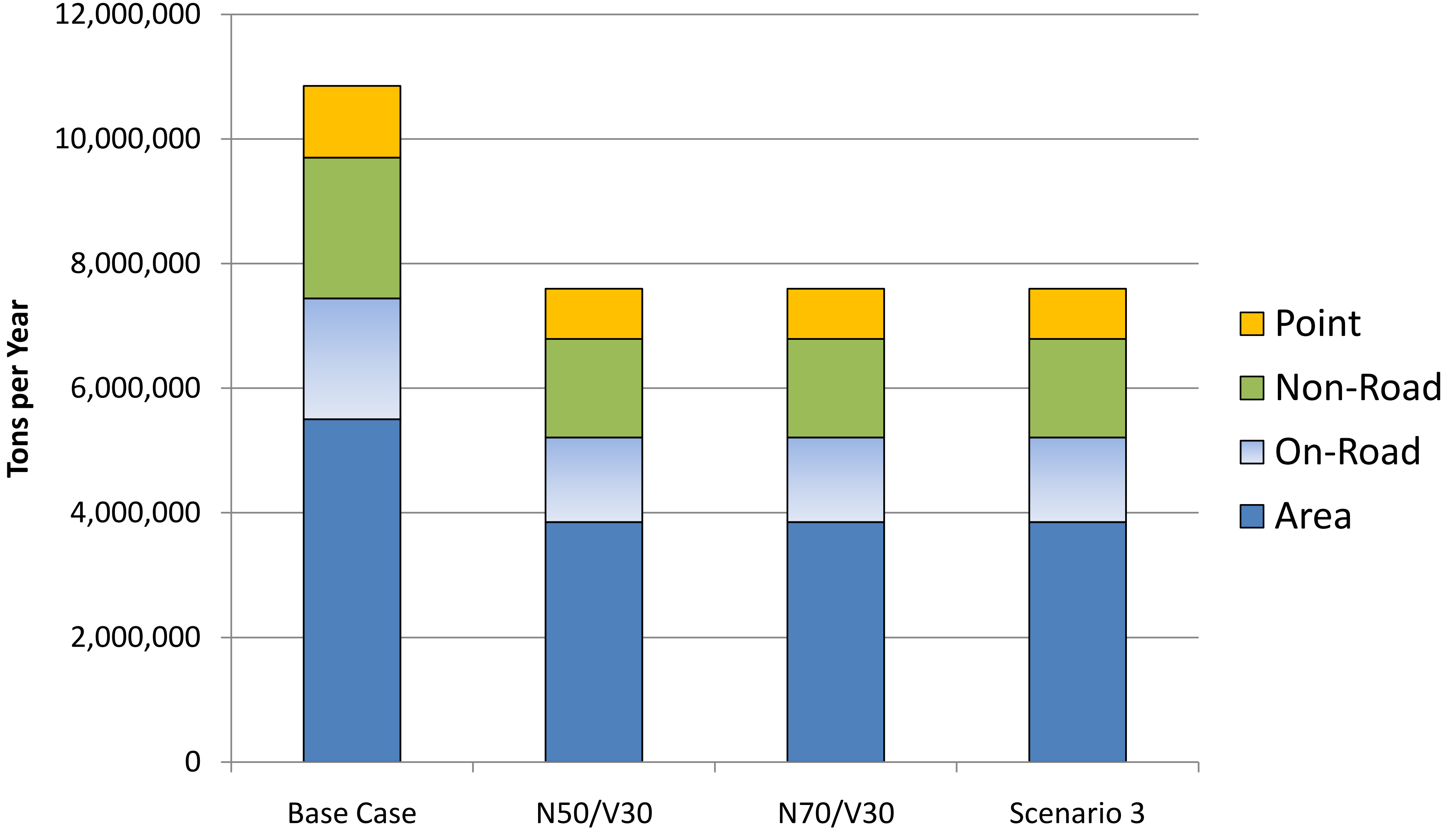
This simulation was performed for May 15 – August 31

NOx Emissions in Screening Runs



- "Scenario 3" approximates an overall 55% NOx reduction
- Includes MOVES adjustments to MOBILE6 emissions

VOC Emissions in Screening Runs



- All screening runs reduce VOC emissions by 30%.
- Includes MOVES adjustments to MOBILE6 emissions

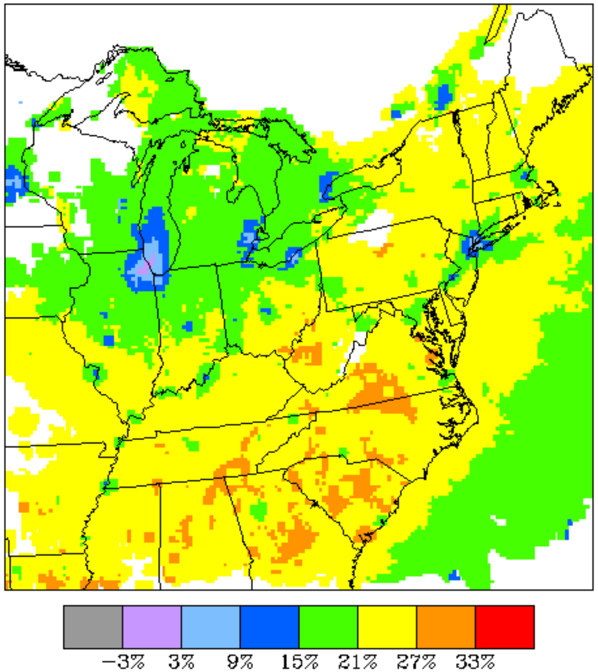
Results

N50V30, N70V30, and “Scenario 3” Simulations

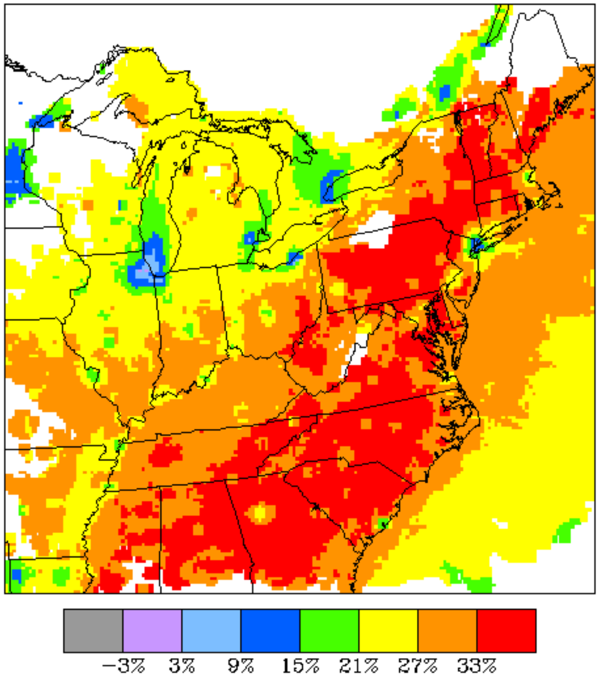
June 1 – August 31

Relative Ozone Reductions

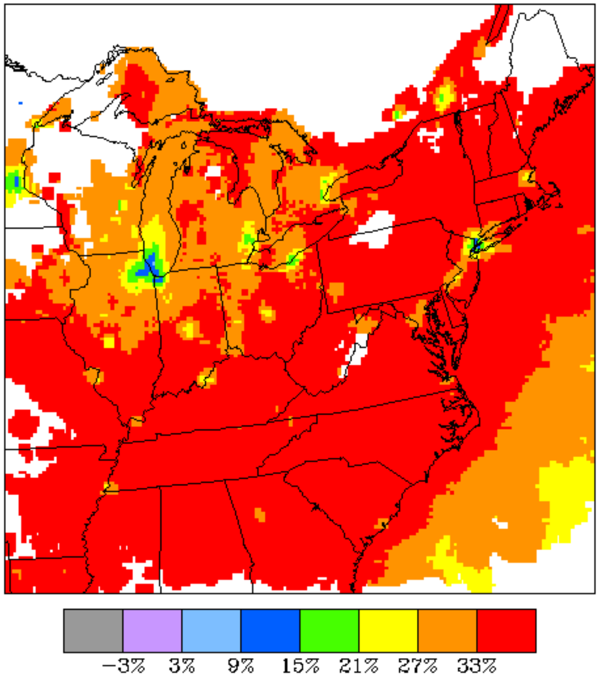
N50/V30



Scenario 3



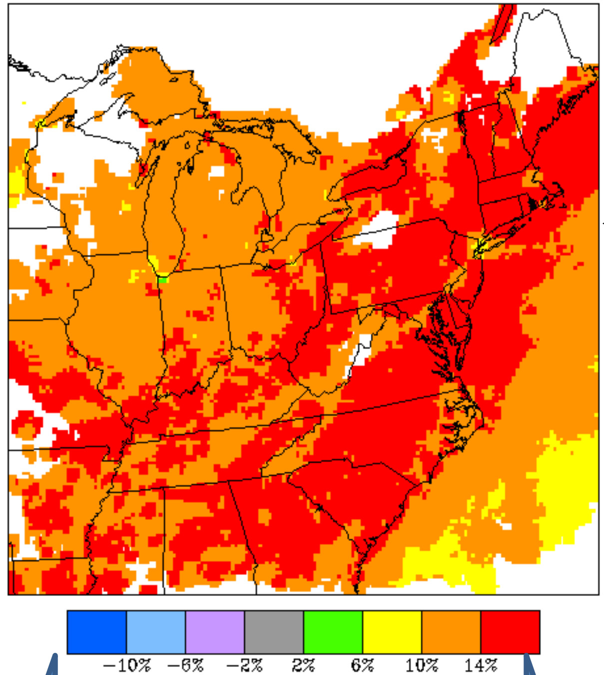
N70/V30



- Ozone reductions from “Scenario 3” run fall between those from the across-the-board reduction simulations
- NO_x focused emission reductions show less benefit for urban core areas

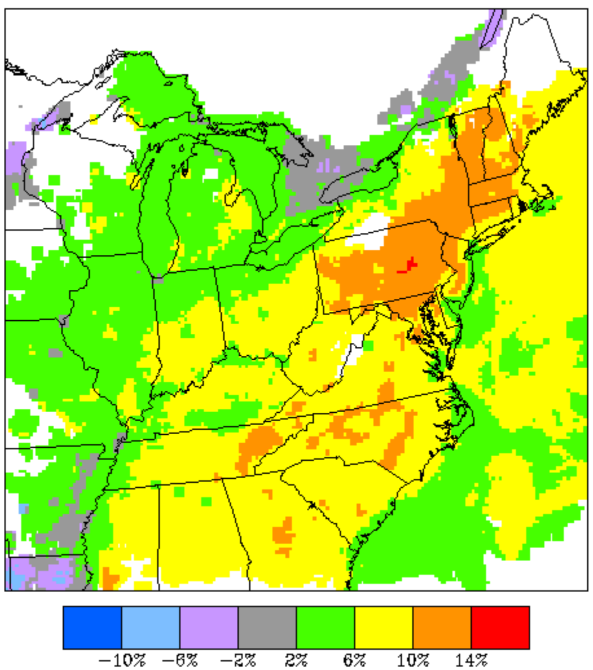
Differences in Relative Ozone Reductions

N70V30 Minus N50V30



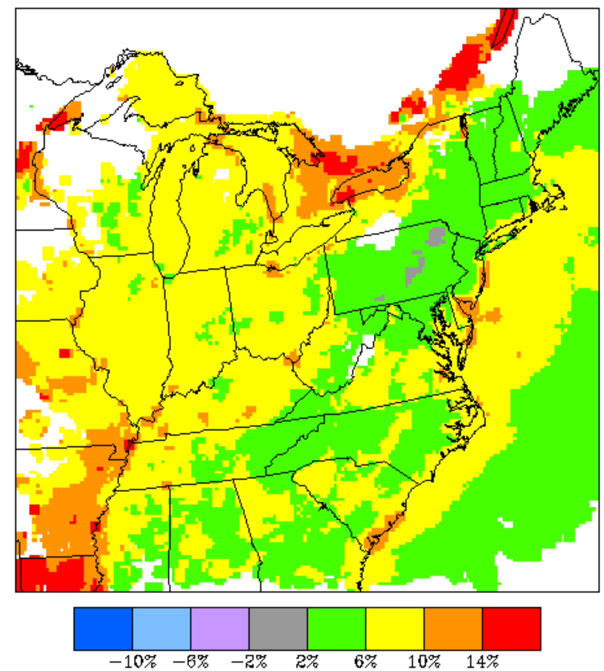
Additional benefit of N70/V30 compared to N50/V30

Scenario 3 Minus N50V30

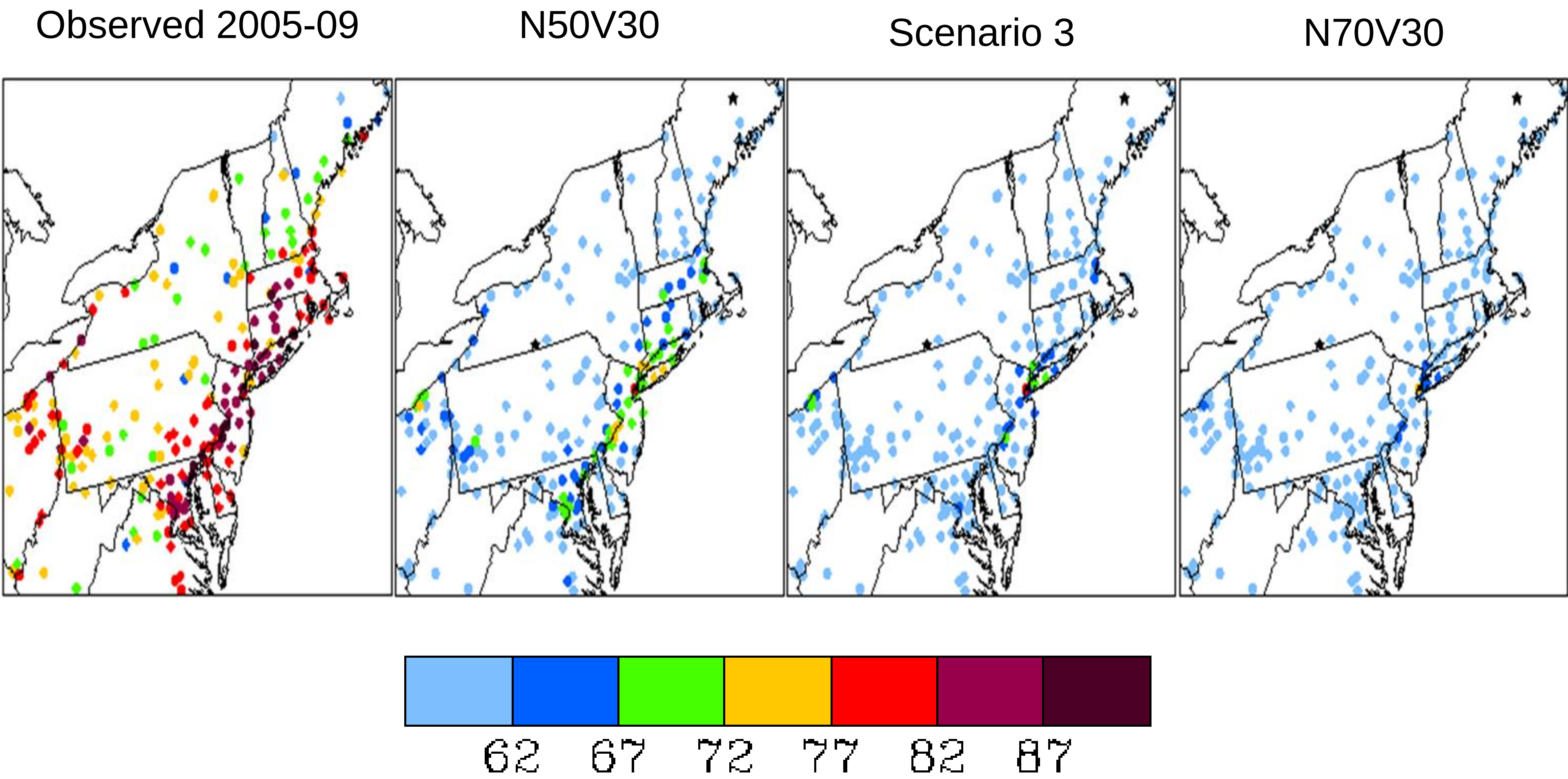


For most of the OTR, “Scenario 3” provides more than **50%** of the additional benefit of N70/V30 compared to N50/V30

N70V30 Minus Scenario 3



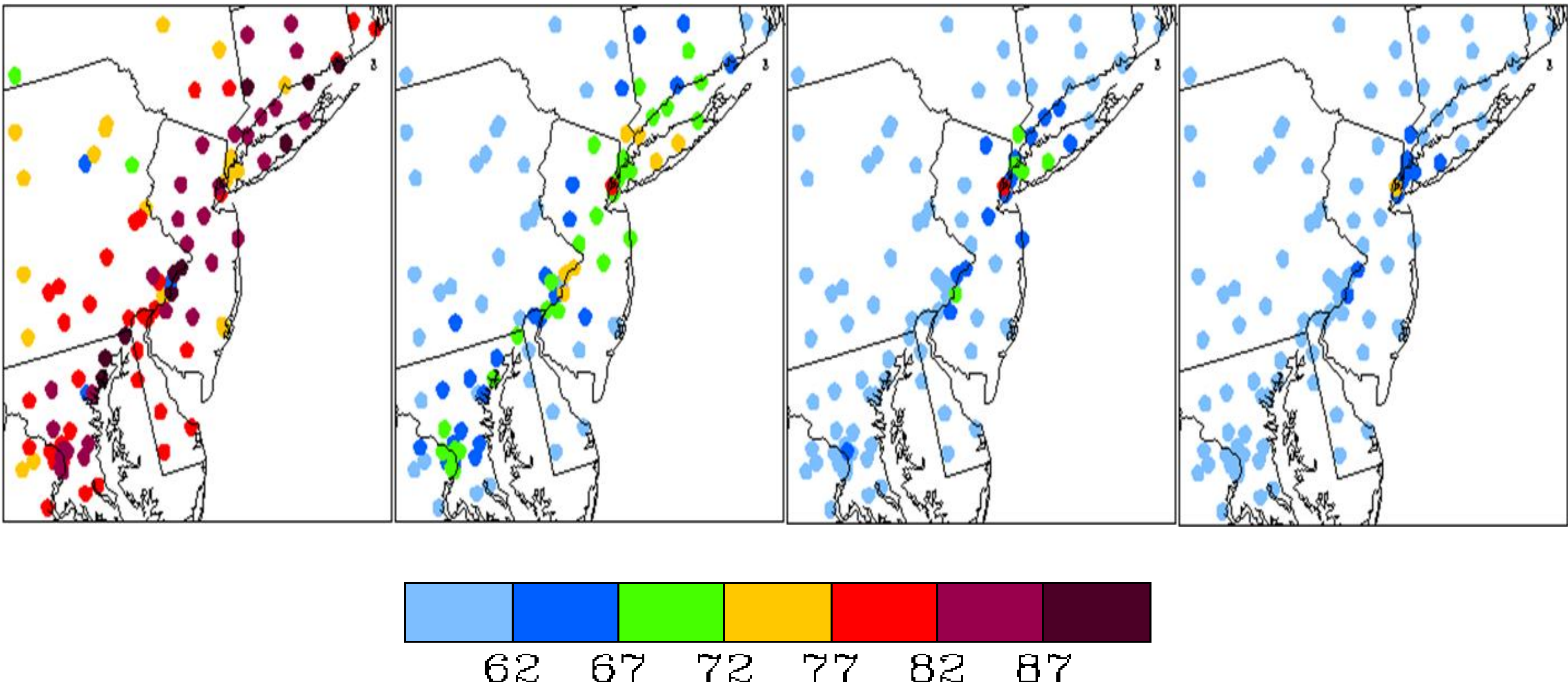
Observed & Predicted Ozone Concentration Design Values



- In N50/V30 across-the-board reductions, hot spots remain in urban areas
- Hot spots are further reduced in “Scenario 3” and N70/V30 reduction scenarios

Observed & Predicted Ozone Concentration Design Values

Observed 2005-09 | N50V30 | Scenario 3 | N70V30



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- Hot spots are further reduced in “Scenario 3” and N70/V30 reduction scenarios

Monitors at Nonattainment Levels

	Base Case		N50/V30		N70/V30		"Scenario 3"	
.08 ppm	34	(18%)	0	(0%)	0	(0%)	0	(0%)
.070 ppm	167	(86%)	16	(8%)	1	(0%)	1	(0%)
.065 ppm	186	(96%)	55	(29%)	4	(2%)	12	(6%)
.060 ppm	191	(98%)	101	(53%)	15	(8%)	29	(15%)
Monitors in OTR	194		190		190		190	

Caveats

- These screening runs use proxy emissions through interpolated inventories for many sectors and regions
- Simplified “MOVES-like” adjustment to MOBILE6 emissions have not been fully tested
- Use of “time invariant clean” boundary conditions
- Screening simulations are based on simplified across-the-board emission reduction approaches

Technical Conclusions

- 2007 Meteorology (WRF) simulation appears to have captured the episode and non-episode periods over the modeling domain as evidenced from observed and predicted ozone pattern

- Ozone levels are somewhat overestimated during episodes over the OTC states – One potential cause could be impact from increased mobile source NO_x from the adoption of MOVES-like mobile source emissions

- In general the N70/V30 reduction case provides increased response of 7 to 11 ppb over N50/V30

- All screening simulations generally give lower ozone reductions in core urban areas such as Bayonne, NJ and Bronx, NY

Policy Conclusions

- An aggressive suite of national measures (in combination with local measures in the OTR) in some targeted sectors as recommended by OTC should help all of the OTR states attain the new standard
- A 50% across the board reduction appears to fall somewhat short of what is needed for full attainment, particularly for the I-95 corridor
- A 70% across-the-board reduction appears to get most areas of the OTR into the low range (60-65 ppb) of the proposed ozone NAAQS
- “Scenario 3” (approximately a 55% reduction) brings several areas of the OTR into the middle of the proposed range

Ongoing Activities: CMAQ Benchmarking

- Benchmarking of CMAQ between participating modeling centers: NJDEP/ORC, UMD, VADEQ, NESCAUM, and NYSDEC
- Goal: Ensure consistency between modeling centers when collaborating on performing the next round of simulations
- Benchmark package consists of
  - CMAQv4.7.1 statically compiled executable
    - CMAQ4.7.1 was released in July 2010 after the completion of the screening simulations
    - No major science updates compared to CMAQ4.7 used in the screening simulations
  - Input files (meteorology, emissions, photolysis rates, initial and boundary conditions)
  - Run scripts

Ongoing Activities: CMAQ Benchmarking

- Benchmark Simulations:
  Modeling period of July 18 – August 9, 2007, for both the 2007 proxy base case and the N50/V30 sensitivity case

- Initial findings:
  Identical results from all modeling centers when using a common statically compiled executable, small differences when using locally compiled executables

Future Activities: Updated Modeling

- Utilize 2007 emission inventories for all sectors and regions
- 36 km continental U.S. and 12 km eastern U.S. simulations with boundary conditions for the 36 km domain obtained from global simulations performed by Georgia DEP
- Extensive model evaluation
- Future year simulations

Extra Slides
Results

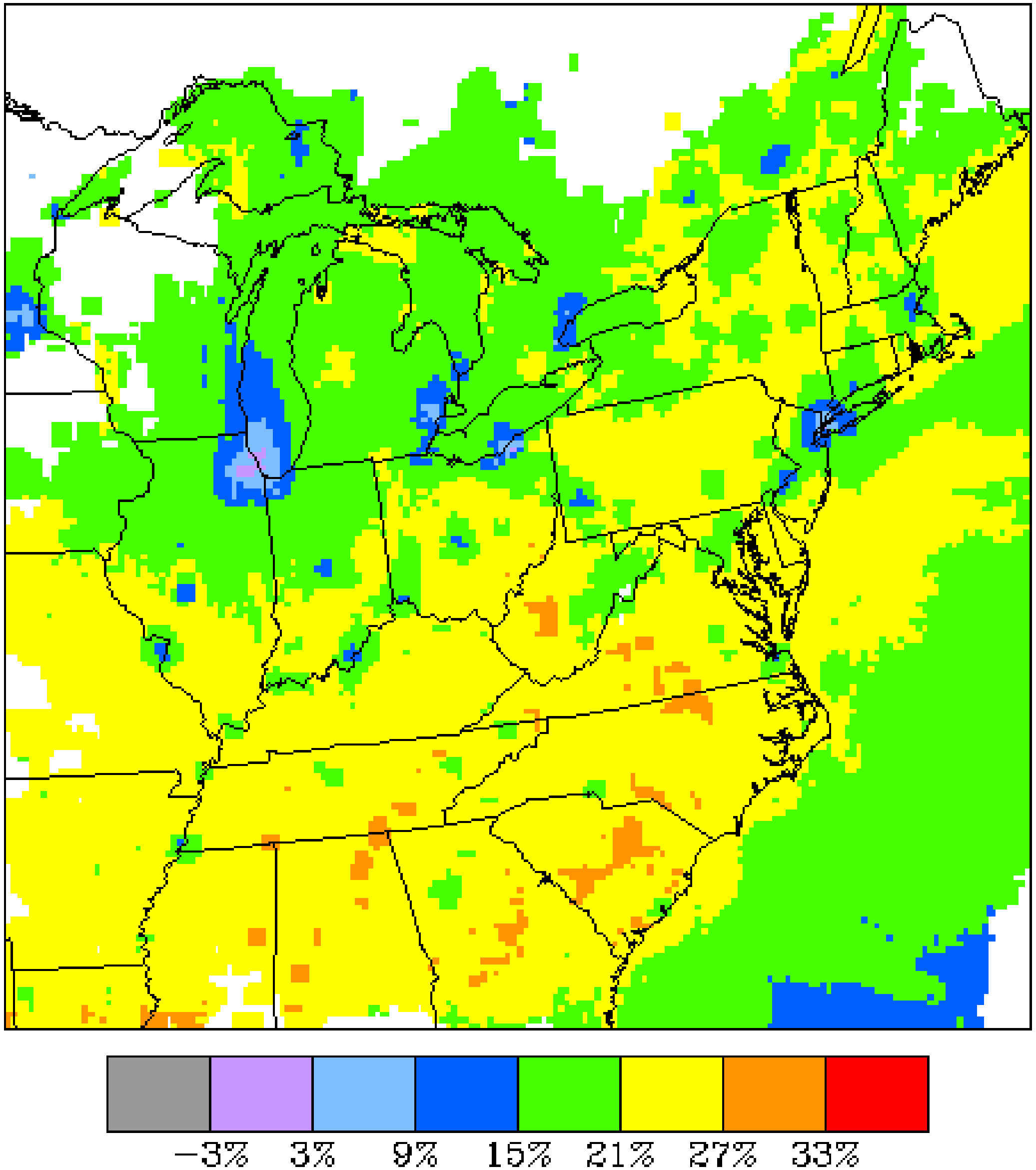
N50V30 and N70V30 Simulations

Analysis Period: April 15 – October 31 (previously shown at June state caucus)

Screening Modeling Results by Monitor, June – August Simulations

Monitor	NAA	DVC 2005 - 2009	DVF 50%NOx/30%VOC	DVF OTC Recommendations	DVF 70%NOx/30%VOC
Bayonne	New York-N. New Jersey-Long Island;NY-NJ-CT	85	81	78	74
Bristol	Philadelphia-Wilmin-Atlantic Ci;PA-NJ-MD-DE	90	76	67	64
Camden	Philadelphia-Wilmin-Atlantic Ci;PA-NJ-MD-DE	87.5	75	68	65
White Plains	New York-N. New Jersey-Long Island;NY-NJ-CT	86.3	75	70	66
Babylon	New York-N. New Jersey-Long Island;NY-NJ-CT	85.3	74	69	64
NEA	Philadelphia-Wilmin-Atlantic Ci;PA-NJ-MD-DE	88	74	65	62
Greenwich	New York-N. New Jersey-Long Island;NY-NJ-CT	86.3	73	67	61
Holtsville	New York-N. New Jersey-Long Island;NY-NJ-CT	88	73	66	61
Clarksboro	Philadelphia-Wilmin-Atlantic Ci;PA-NJ-MD-DE	85.7	72	64	61
Rudgers U	New York-N. New Jersey-Long Island;NY-NJ-CT	86.3	72	63	60
NYC-Queens	New York-N. New Jersey-Long Island;NY-NJ-CT	76.7	72	69	67
Stratford	New York-N. New Jersey-Long Island;NY-NJ-CT	87	71	64	58
McMillan Reservoir	Washington; DC-MD-VA	84.7	71	63	60
Rider U	Philadelphia-Wilmin-Atlantic Ci;PA-NJ-MD-DE	86.3	71	62	59
Ramapo	New York-N. New Jersey-Long Island;NY-NJ-CT	85.3	71	63	61
NYC-IS52	New York-N. New Jersey-Long Island;NY-NJ-CT	73.3	71	68	66

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

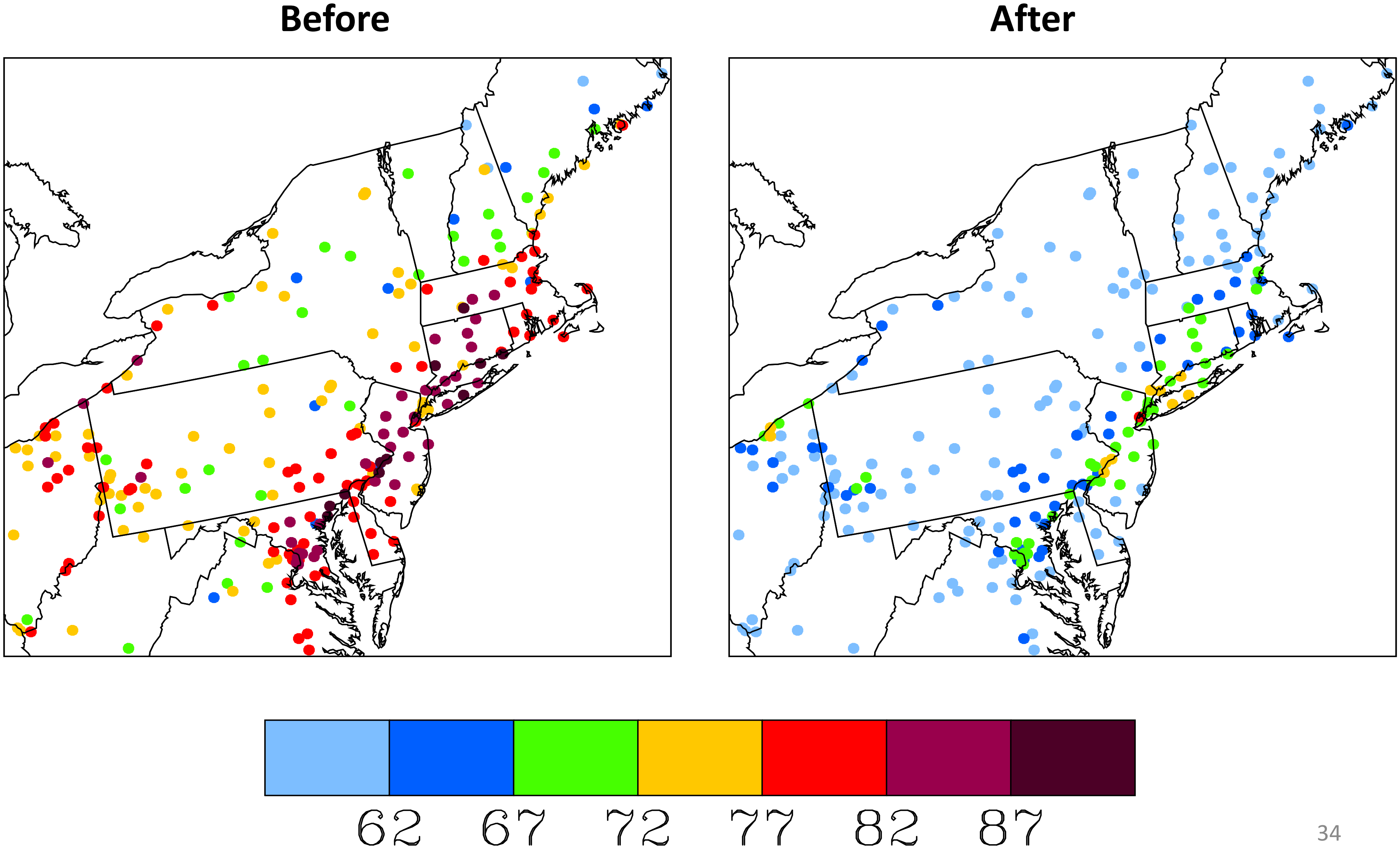


NO_x- focused emission reductions show less benefit for urban core areas

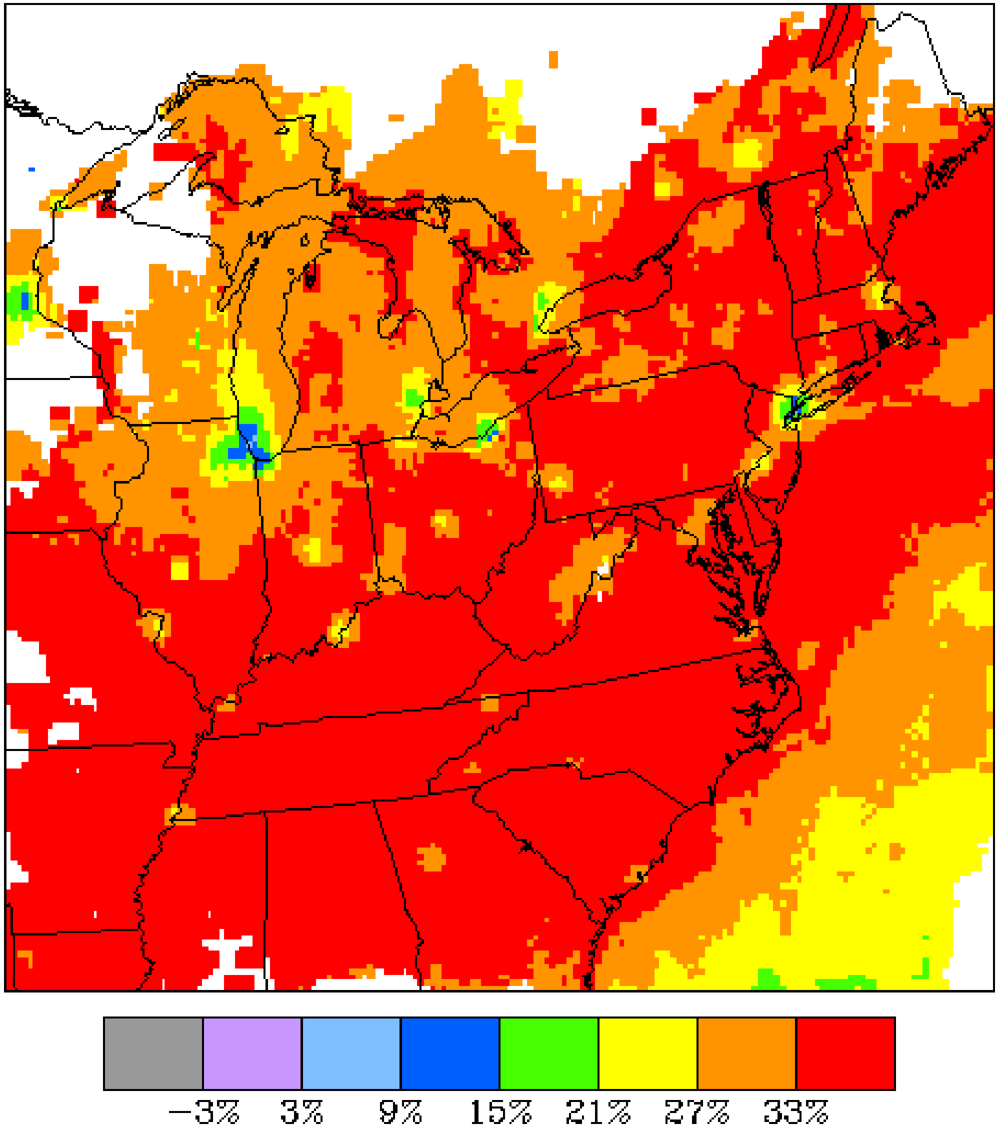
Model Predicted Ozone Concentration Design Values

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

Hot Spots remain in Urban Areas



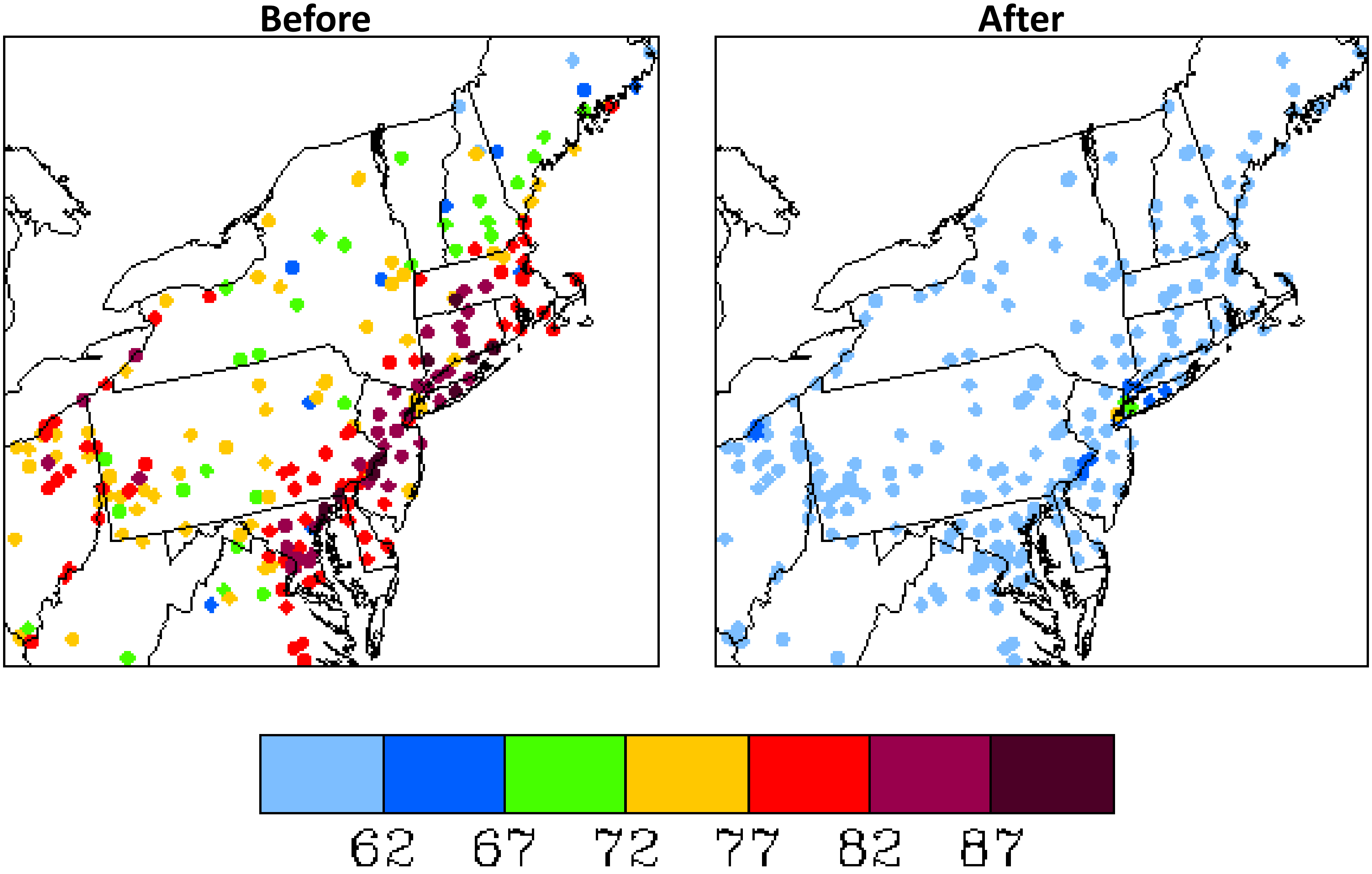
Relative Ozone Reductions Due to 70% NOx and 30% VOC Reductions



- Larger ozone reductions throughout than earlier screening run.
- Overall ozone reductions generally greater than 27% except for core urban areas.

Model Predicted Ozone Concentration Design Values

With 70% NOx and 30% VOC Reductions Across-the-Board



Screening Modeling Results by Monitor

April – October "Across-The-Board" Simulations

Monitor	NAA	DVC 2005 - 2009	DVF 50%NOx/30%VOC	DVF 70%NOx/30%VOC
Bayonne	New York-N. New Jersey-Long Island;NY-NJ-CT	85	81	74
Bristol	Philadelphia-Wilmin-Atlantic Ci;PA-NJ-MD-DE	90	77	66
White Plains	New York-N. New Jersey-Long Island;NY-NJ-CT	86.3	76	67
Babylon	New York-N. New Jersey-Long Island;NY-NJ-CT	85.3	76	66
Camden	Philadelphia-Wilmin-Atlantic Ci;PA-NJ-MD-DE	87.5	75	65
NEA	Philadelphia-Wilmin-Atlantic Ci;PA-NJ-MD-DE	88	75	64
Greenwich	New York-N. New Jersey-Long Island;NY-NJ-CT	86.3	74	63
Holtsville	New York-N. New Jersey-Long Island;NY-NJ-CT	88	74	63
Stratford	New York-N. New Jersey-Long Island;NY-NJ-CT	87	73	61
NYC-IS52	New York-N. New Jersey-Long Island;NY-NJ-CT	73.3	72	68
NYC-Queens	New York-N. New Jersey-Long Island;NY-NJ-CT	76.7	72	68
Ramapo	New York-N. New Jersey-Long Island;NY-NJ-CT	85.3	72	62
Clarksboro	Philadelphia-Wilmin-Atlantic Ci;PA-NJ-MD-DE	85.7	72	61
Rider U	Philadelphia-Wilmin-Atlantic Ci;PA-NJ-MD-DE	86.3	72	61
Rutgers U	New York-N. New Jersey-Long Island;NY-NJ-CT	86.3	72	60
NYC-Susan Wagner HS	New York-N. New Jersey-Long Island;NY-NJ-CT	80.7	71	63
Lynn	Boston-Lawrence-Worcester (E. MA); MA	81.3	71	61
Westport	New York-N. New Jersey-Long Island;NY-NJ-CT	85.3	71	60
McMillan Reservoir	Washington; DC-MD-VA	84.7	71	60
Chicopee	Springfield (Western MA); MA	88	71	59
Danbury	New York-N. New Jersey-Long Island;NY-NJ-CT	88.7	71	58
Middletown	New York-N. New Jersey-Long Island;NY-NJ-CT	87	71	58