Regional Photochemical Modeling for the Kansas City Clean Air Action Plan: What it Tells Us About the Challenges Ahead for 8-Hr Ozone Nonattainment Areas

Prepared by:

Neil Wheeler, Lyle Chinkin, and Steve Reid

Sonoma Technology, Inc.

Petaluma, CA

Presented to:

4th Annual CMAS Models-3 User's Conference

Chapel Hill, NC

September 26-28, 2005

Sonoma Technology, Inc.

Coauthors

Tom Gross, Andy Hawkins, and Doug Watson
Kansas Department of Health and Environment
Topeka, KS

Wendy Vit and Refaat Mefrakis
Missouri Department of Natural Resources
Jefferson City, MO

James Joerke
Mid-America Regional Council
Kansas City, MO

Sonoma Technology, Inc.

Overview

- Introduction
- Modeling approach
- Model performance
- Future-year simulations
- Discussion
- Summary and conclusions

Sonoma Technology, Inc.

Introduction

- Kansas City (KC) 8-hr ozone in 2003
- MARC Air Quality Forum and Air Quality Working Group
- Clean Air Action Plan (CAAP)
- Earlier modeling efforts: three episodes
- KDHE modeling: August 15-21, 1998

Sonoma Technology, Inc.

Modeling Approach (1 of 2)

- Pennsylvania State University/NCAR Mesoscale Model (MM5) with four-dimensional data assimilations
- 1996 National Emission Trends inventory projected to 1998
  - Updates for KS and MO stationary sources
  - Onroad mobile sources: MOBILE6
  - Link-based vehicle miles traveled (VMT) for KC and St. Louis
  - Offroad mobile sources: NONROAD
  - Biogenic sources: BEIS3
- Sparse Matrix Operator Kernel Emissions (SMOKE) processing system Version 2

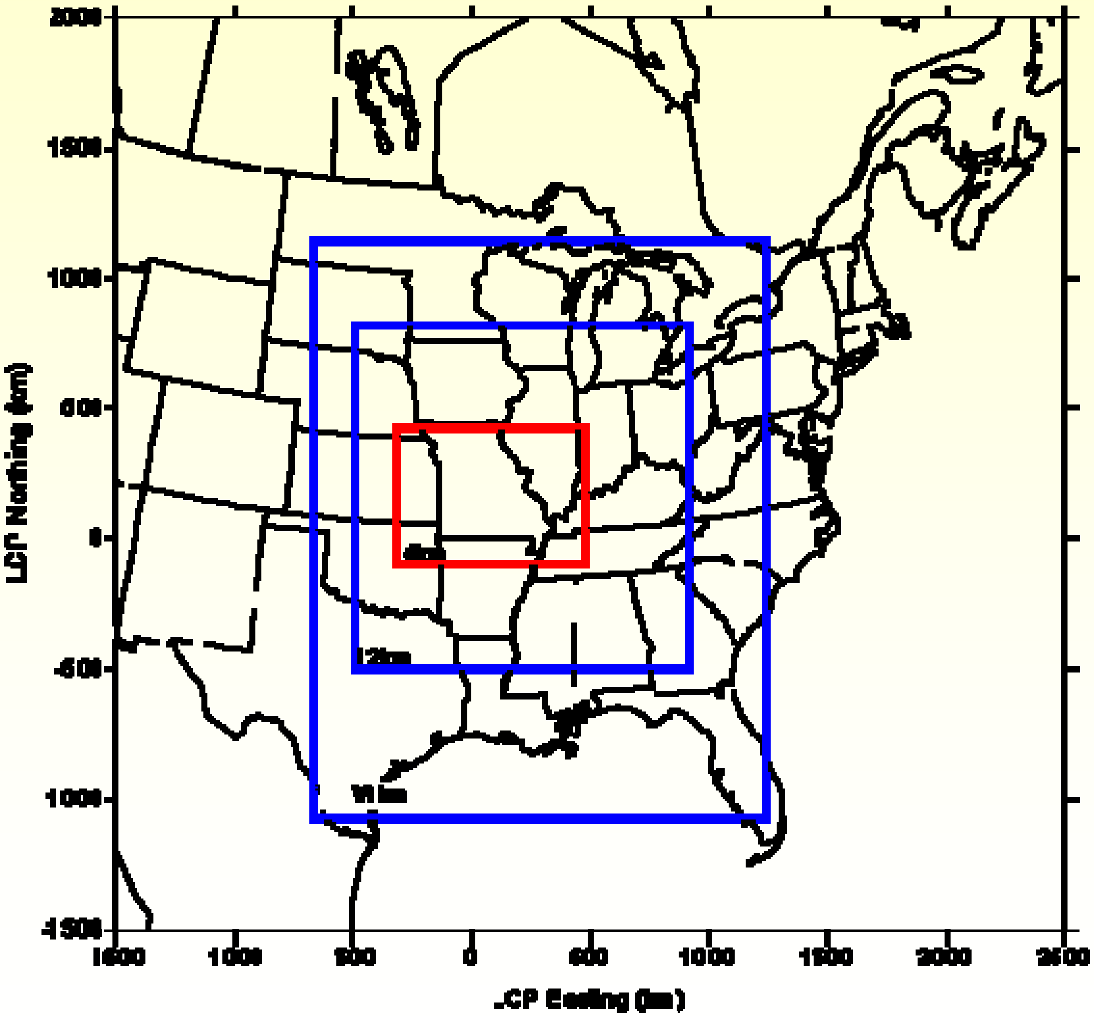
Sonoma Technology, Inc.

Modeling Approach (2 of 2)

- CAMx Version 3.10
  - Chemistry: Carbon Bond IV (Mechanism 3)
  - Initial conditions: OTAG “clean”
  - Top boundary conditions: OTAG “clean”
  - Lateral boundary conditions: 51 ppb ozone for outer domain
  - Advection: Piece-wise parabolic method
  - Minimum K_v: 0.1 – 1.0 with the “kvpatch” program

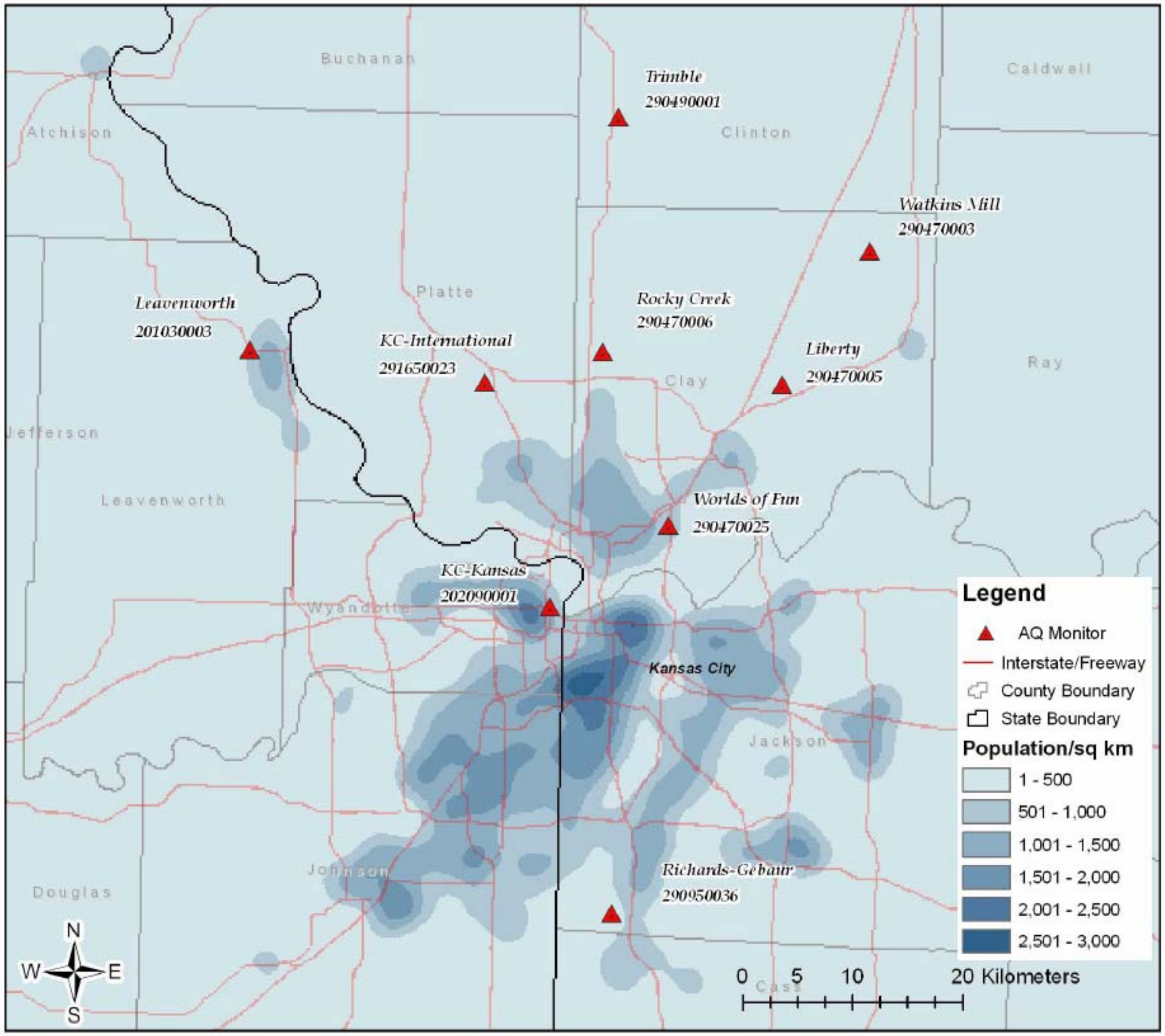
Sonoma Technology, Inc.

Modeling Domains



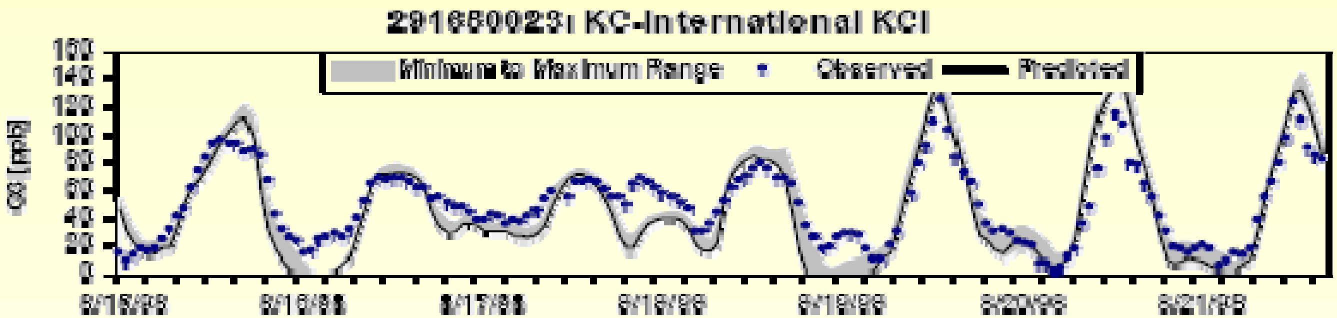
Sonoma Technology, Inc.

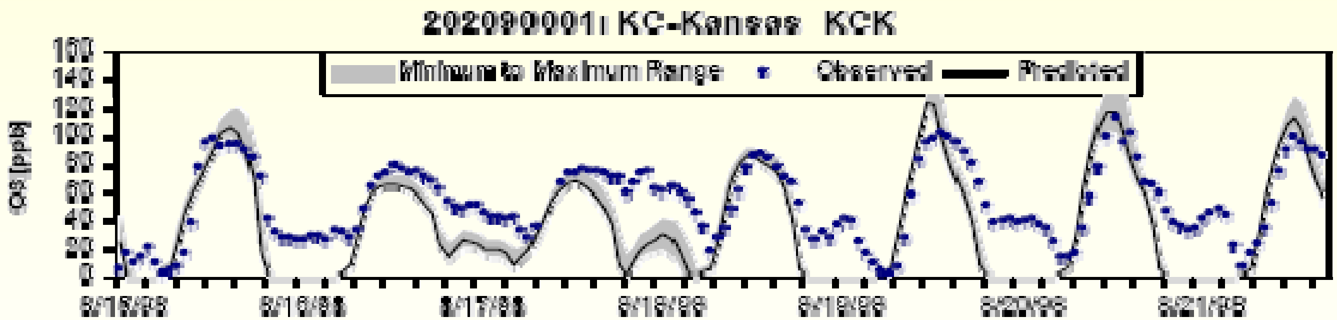
Monitoring Sites

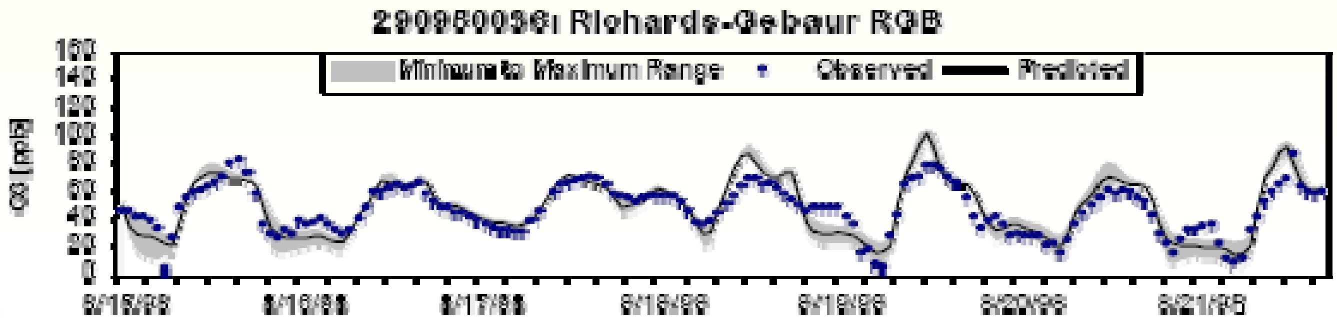


Sonoma Technology, Inc.

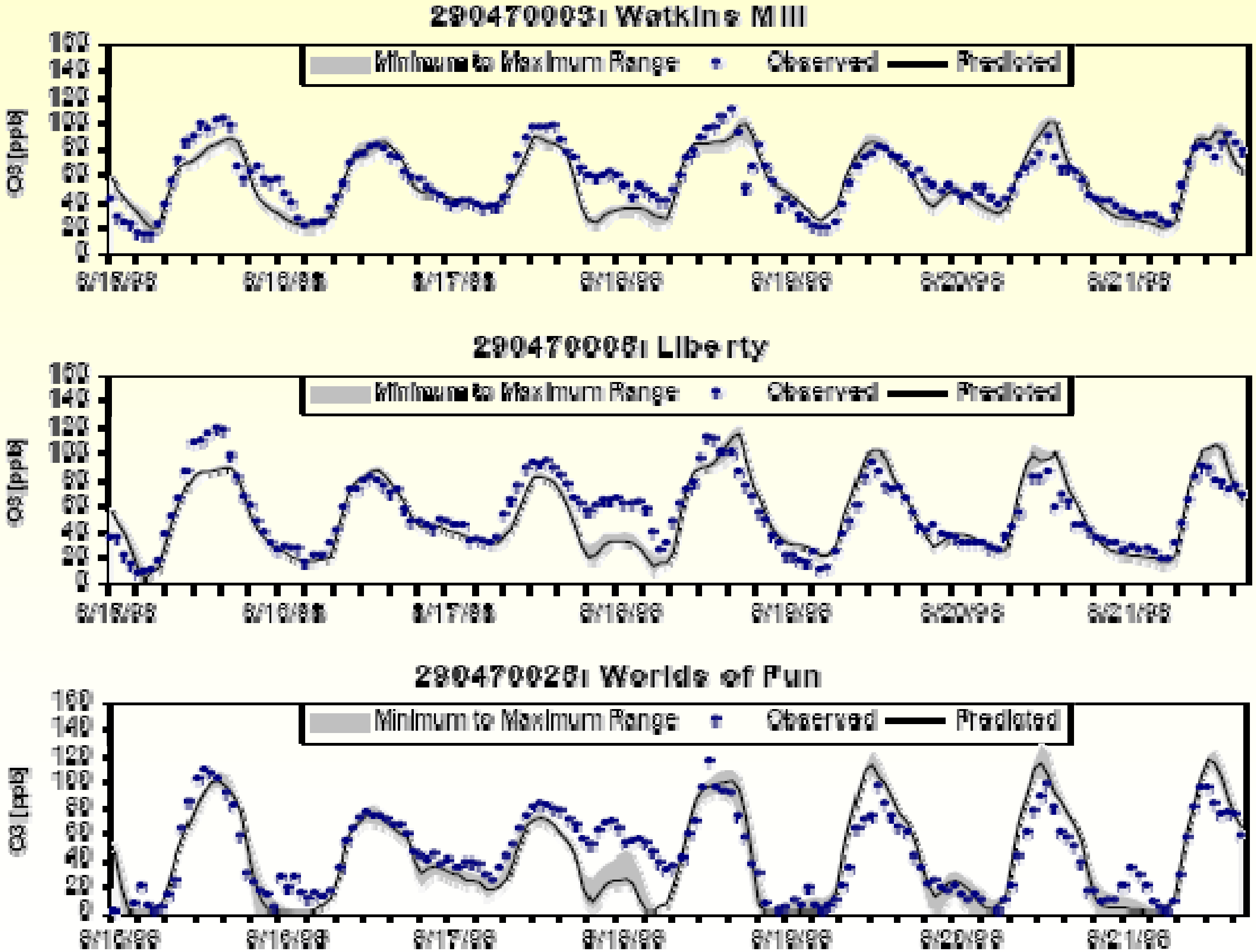
Model Performance (1 of 3)





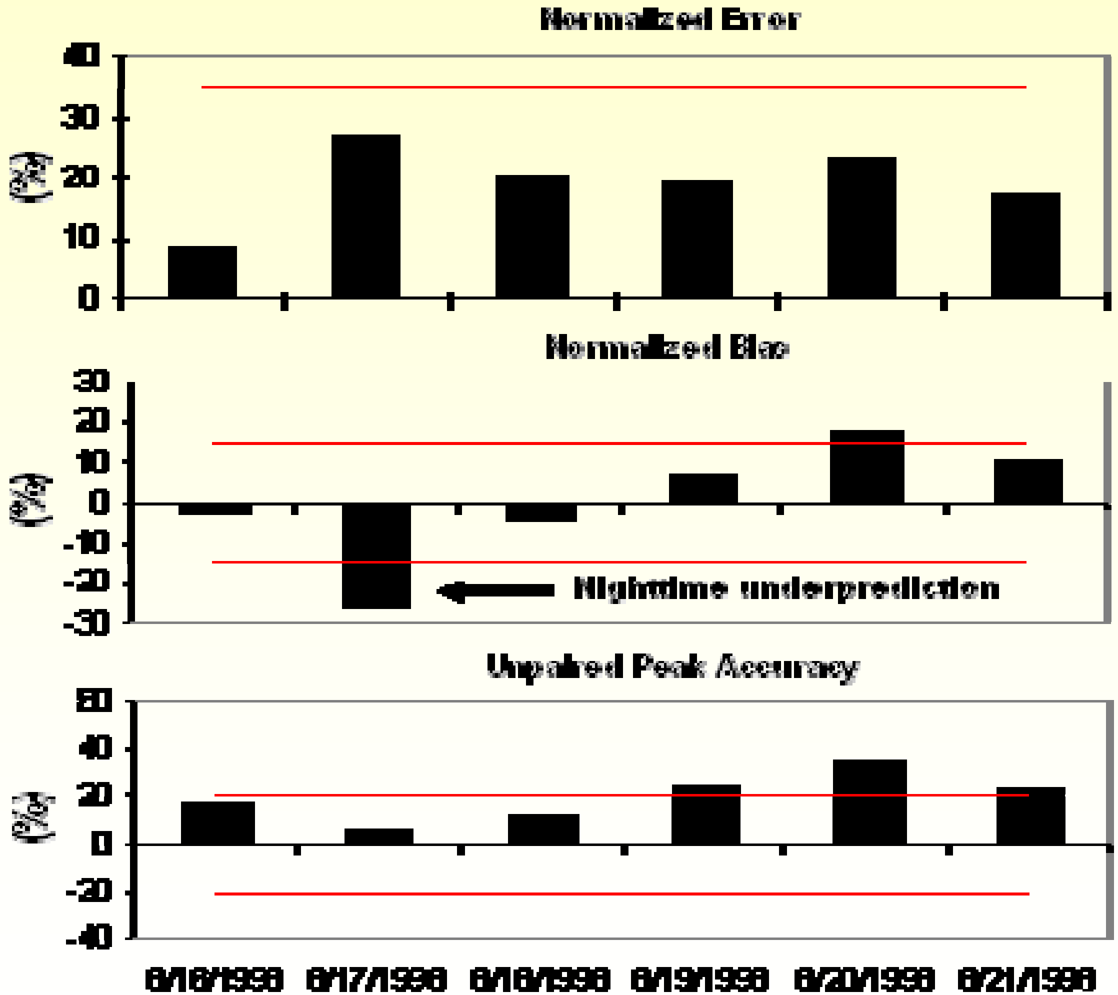


Model Performance (2 of 3)



Sonoma Technology, Inc.

Model Performance (3 of 3)



Sonoma Technology, Inc.

Future-Year Simulations (1 of 2)

- Year 2010
- Area sources
  - 1999 National Emission Inventory (NEI) using growth factors from EPA's Economic Growth Analysis System (EGAS).
  - For some source categories, such as locomotives and commercial marine vessels, alternative growth factors were chosen in keeping with federal regulatory support documents.
  - Controls for existing federal control measures.
- Onroad mobile sources – MOBILE6 with EGAS projected VMT
- Offroad mobile sources – NONROAD

Sonoma Technology, Inc.

Future-Year Simulations (2 of 2)

- Stationary sources
  - Electric Generating Units (EGU)
    - Integrated planning model from the Clear Skies Initiative
    - Surveys for KS and MO
  - Non-EGU sources – EGAS growth factors
- Across-the-board emission reductions
- Specific emission control scenarios

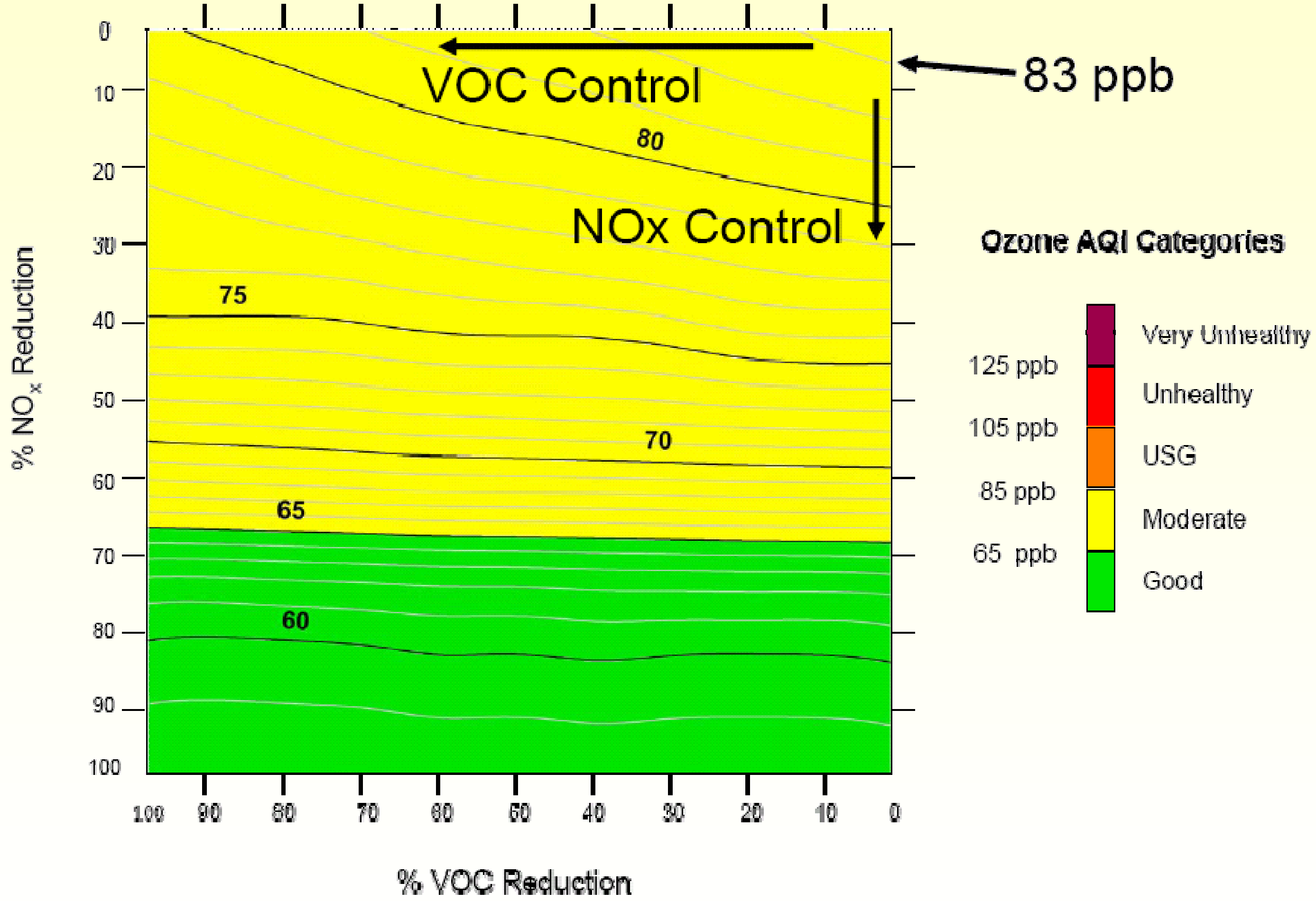
Sonoma Technology, Inc.

2010 KC Area Emissions

Source Type	2010 Emissions (tons/day)	
	VOC	NO_x
Area Sources	111	29
Nonroad Mobile Sources	32	78
Onroad Mobile Sources	52	72
Point Sources	32	226
Total	227	404

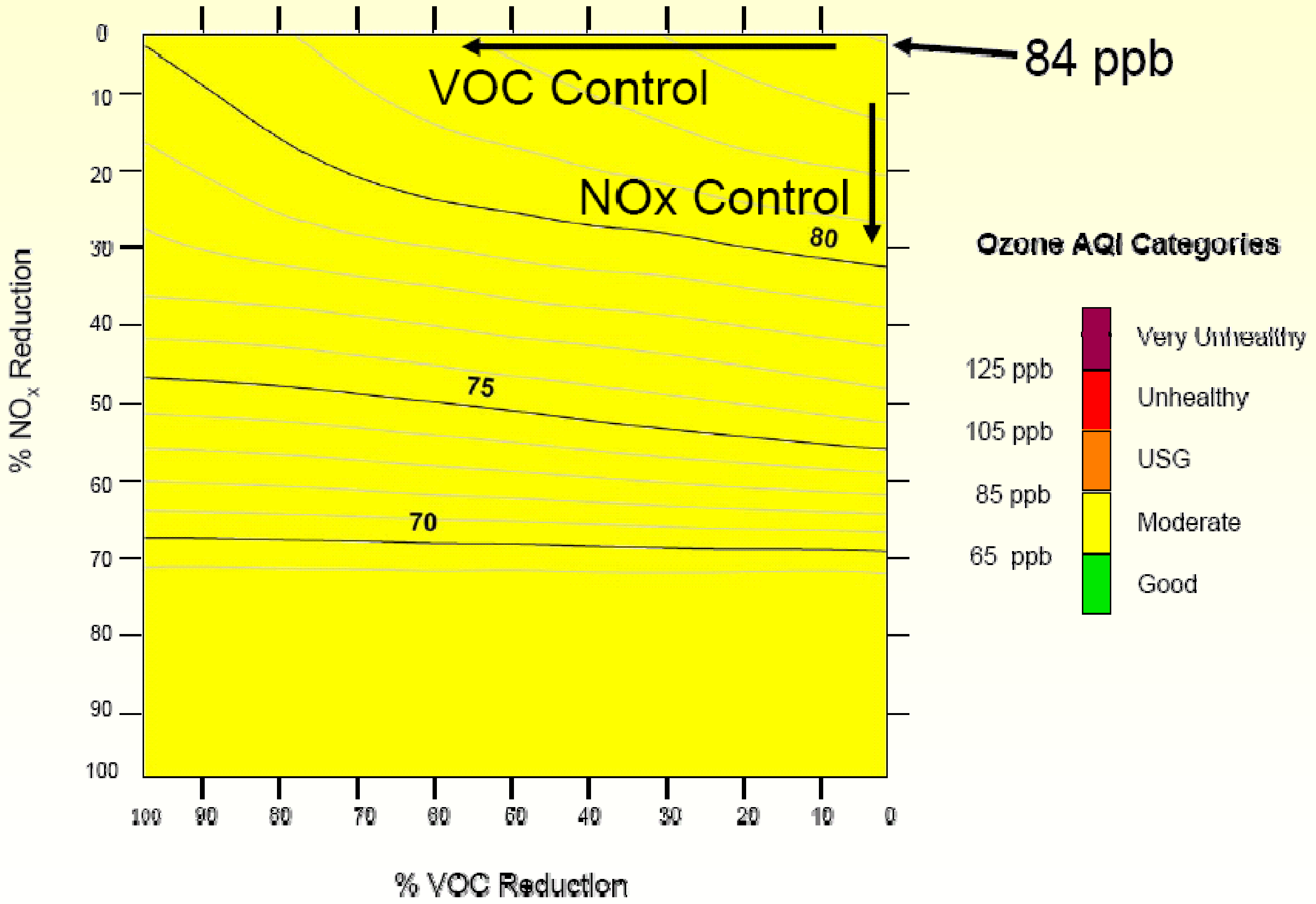
Sonoma Technology, Inc.

KC Area Peak 8-hr Ozone Isopleth Diagram for August 21, 2010



Sonoma Technology, Inc.

KC Area Peak 8-hr Ozone Isopleth Diagram for August 19, 2010



Sonoma Technology, Inc.

Emission Control Scenarios Modeled

Control Scenario		Emission Reduction (tons/day)		Largest decrease in peak 8-hr ozone (ppb)
#	Description	VOC	NO_x	
C01	All voluntary measures (conservative)	0.6	0.9	0.07
C02	All voluntary measures (aggressive)	-0.5	73.6	1.50
C03	All regulatory and voluntary measures; aggressive voluntary; maximum expected reductions	5.0	79.1	1.98
C04	All regulatory measures	5.7	5.7	0.48
C05	Voluntary measures (aggressive) without power plant reductions	1.5	2.6	0.63

Sonoma Technology, Inc.

Discussion (1 of 2)

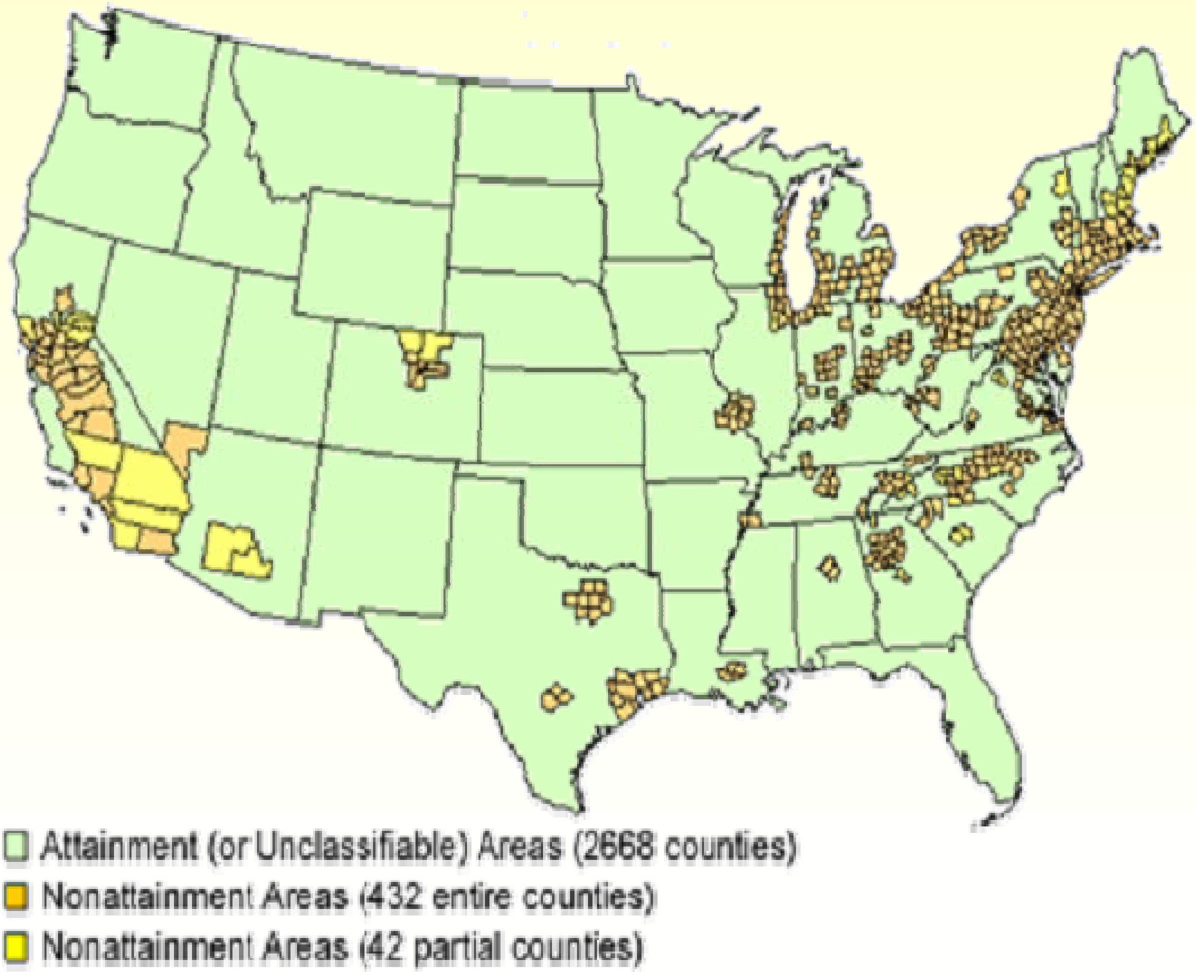
- Limitations
- Eliminating all emissions in the KC area only reduced the peak 8-hr ozone concentrations by 18 to 30%.
- Approximately 24% of the peak 8-hr ozone concentrations in 2010 will be attributable to local emissions while global background and regional transport will contribute 41% and 35%, respectively.
- Federal and state emissions controls between 1998 and 2010 will reduce peak 8-hr ozone concentrations in the KC area by 9.4%.
- Moderate additional local emission controls will only reduce peak 8-hr ozone concentrations by, at most, another 2%.

Discussion (2 of 2)

- The greatest reductions in ozone concentrations are predicted to occur in areas that do not typically measure the highest ozone concentrations (e.g., Johnson County).
- The modeling also indicates that peak ozone concentrations will be further downwind of KC than historically observed.
- Regions in the modeling domain between major cities are predicted to have ozone concentrations similar to those upwind of KC.
- Because so many of newly designated 8-hr ozone nonattainment areas are located in these regions, they may also see a similar ozone response to local emission controls.

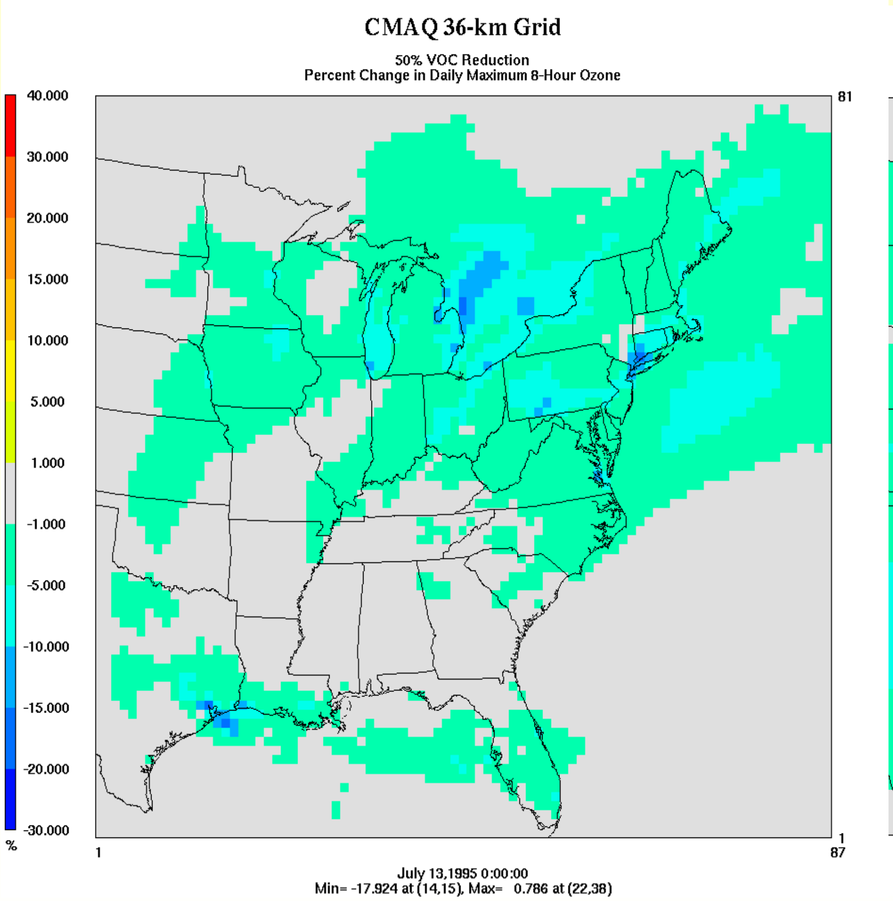
Sonoma Technology, Inc.

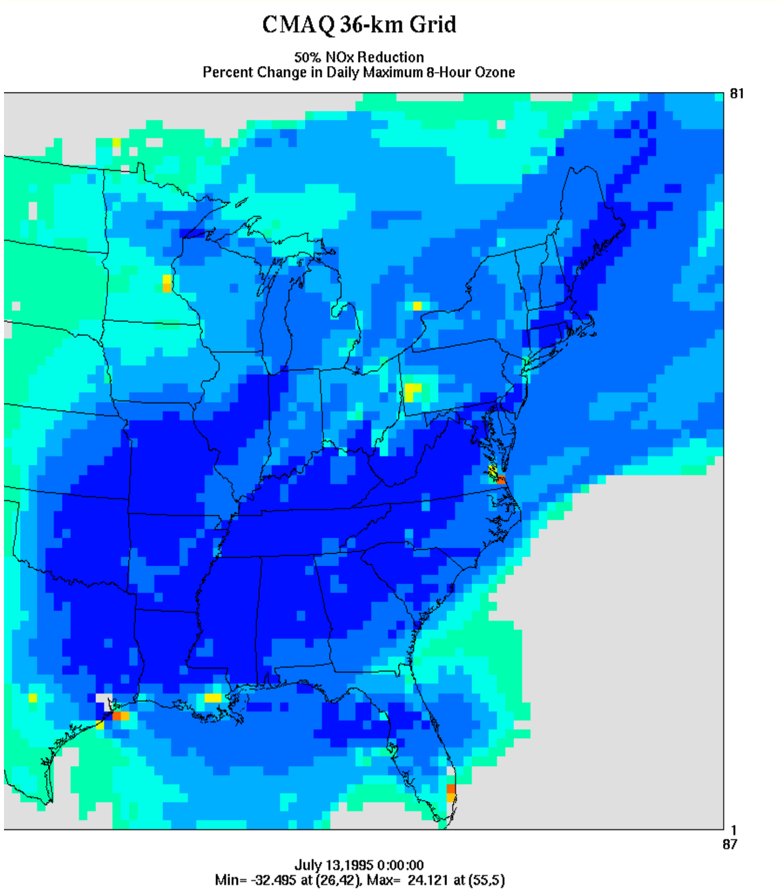
8-hr Ozone Nonattainment Areas



Sonoma Technology, Inc.

CMAQ Predicted Change in Peak 8-hr Ozone Concentrations





Summary and Conclusions (1 of 2)

- Modeling was performed for only one episode.
- Results indicate that the KC area will be barely in attainment of the 8-hr ozone standard in 2010.
- Additional local controls may provide a buffer against nonattainment for 8-hr ozone.
- In addition, these local controls have a potential to reduce ambient concentrations of particulate matter, greenhouse gases, and hazardous air pollutants.

Summary and Conclusions (2 of 2)

- Many of the new nonattainment areas in the central and eastern United States may have difficulty demonstrating attainment with local controls alone.
- As states begin to develop their State Implementation Plans for 8-hr ozone, the role of controlling regional ozone will need to be revisited.

STI Sonoma Technology, Inc.

Acknowledgements

- KDHE and MDNR: meteorological, emissions, and air quality modeling.
- MARC and KDHE: Funding for CAAP modeling.
- EPA Region 7: Emissions and AQ modeling support.
- EPRI and TCEQ: Funding the NARSTO Model Inter-comparison Study.

Sonoma Technology, Inc.

Questions?

Neil Wheeler
Sonoma Technology, Inc.
1360 Redwood Way, Suite C
Petaluma, CA 94954

707-665-9900

neil@sonomatech.com

www.sonomatech.com

Sonoma Technology, Inc.