
Implementing a Hybrid CMAQ/AERMOD Modeling Approach to Address PM_{2.5} Nonattainment in Granite City, IL

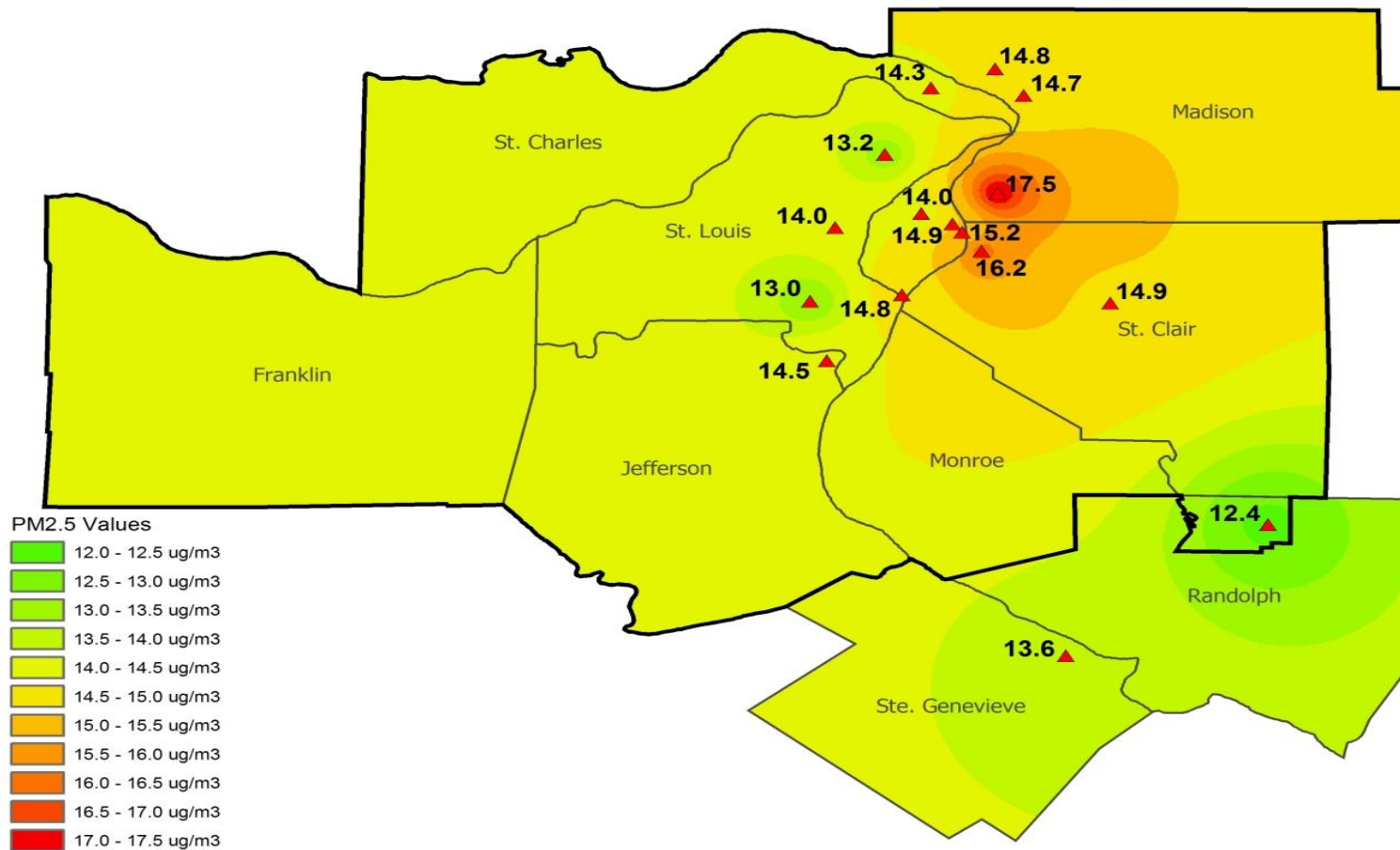
Jeffrey Sprague, Illinois EPA (Bureau of Air)

Advanced CAMx Training and LADCO Regional Modeling Meeting

August 4, 2010

Rosemont, Illinois

St. Louis Region 2001-2003 Annual PM2.5 Design Values



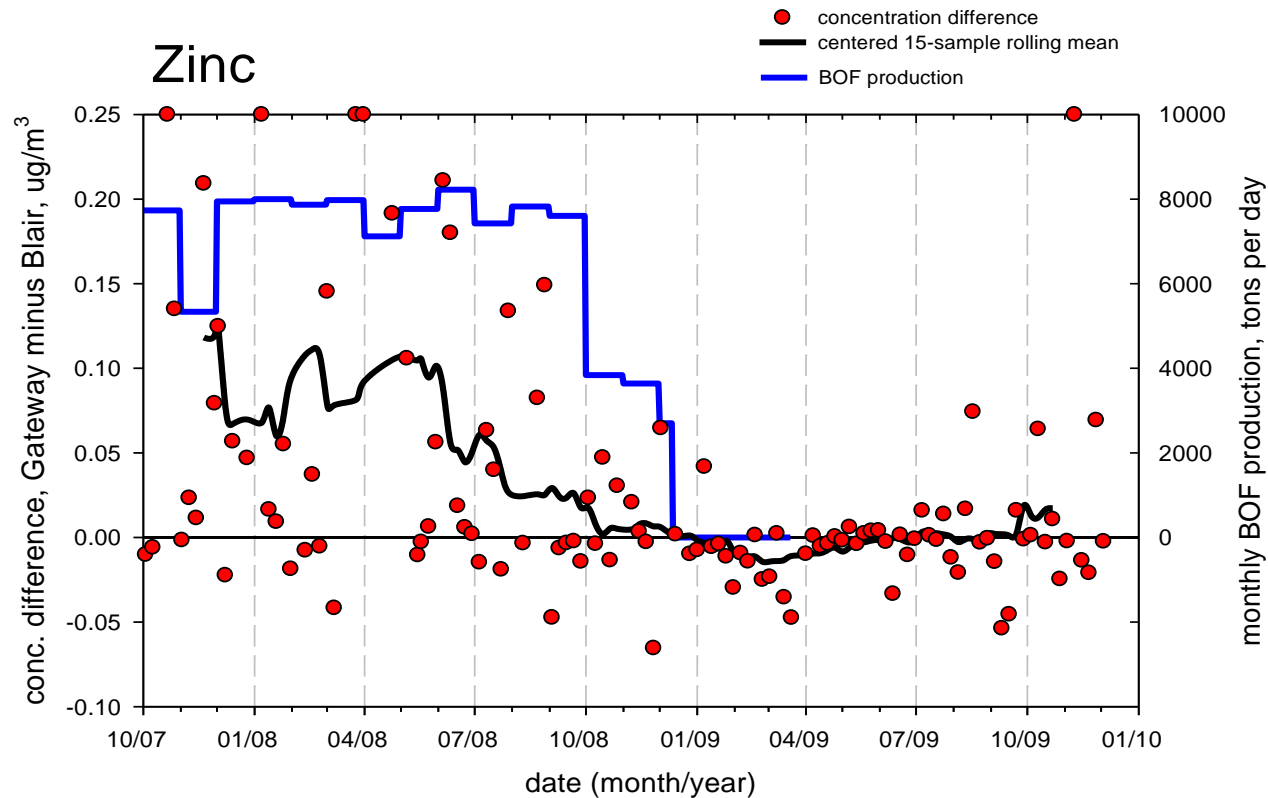
PM_{2.5} Annual Average Concentrations & Three Year Design Values

Monitor Site	PM _{2.5} Annual Concentrations (µg/m ³)								PM _{2.5} Annual Design Values (µg/m ³)					
	2002	2003	2004	2005	2006	2007	2008	2009	02-04	03-05	04-06	05-07	06-08	07-09
<u>Missouri</u>														
West Alton	14.2	14.0	11.9	15.2	11.6	13.2	Disc	Disc	13.4	13.7	12.9	13.3	Disc	Disc
Margaretta	14.3	13.5	12.1	15.3	12.8	Disc	Disc	Disc	13.3	13.6	13.4	Disc	Disc	Disc
Blair Street	15.4	14.1	13.2	16.1	13.4	13.9	12.9	11.5	14.2	14.5	14.2	14.5	13.4	12.8
South Broadway	15.3	14.4	13.1	15.9	13.1	14.0	12.5	11.9	14.3	14.5	14.0	14.3	13.2	12.8
Mound Street Branch	15.6	14.7	13.6	15.9	13.7	14.3	12.7	11.5	14.6	14.7	14.4	14.6	13.6	12.8
Oakville							13.4	12.0					**	**
Clayton	14.6	13.6	12.2	15.5	11.8	13.1	12.0	11.3	13.5	13.8	13.2	13.5	12.3	12.1
Sunset Hills	13.0	13.0	11.6	14.6					12.5	13.1				
Arnold*	15.0	14.0	12.6	15.4	12.6	13.7	11.6	9.0	13.9	14.0	13.5	13.9	12.6	11.4
<u>Illinois</u>														
Granite City	17.7	17.5	15.4	18.2	16.3	15.1	15.7	11.3	16.9	17.0	16.6	16.5	15.7	14.0
Alton	14.7	14.0	11.5	16.0	13.1	14.9	12.5	10.2	13.4	13.8	13.5	14.7	13.5	12.5
Wood River	15.1	14.0	13.2	16.0	13.1	14.2	12.2	11.0	14.1	14.4	14.1	14.4	13.2	12.5
E. St. Louis	16.6	14.8	14.7	17.1	14.5	15.6	12.6	11.7	15.4	15.5	15.4	15.7	14.2	13.3
Swansea	15.1	14.3	13.2	16.0	13.4	13.3	12.6	11.7	14.2	14.5	14.2	14.2	13.1	12.5
Houston	11.6	13.4	10.9	15.2	11.4	14.2	10.4	9.7	12.0	13.2	12.5	13.6	12.0	11.4

*-combination of Arnold and Arnold West sites

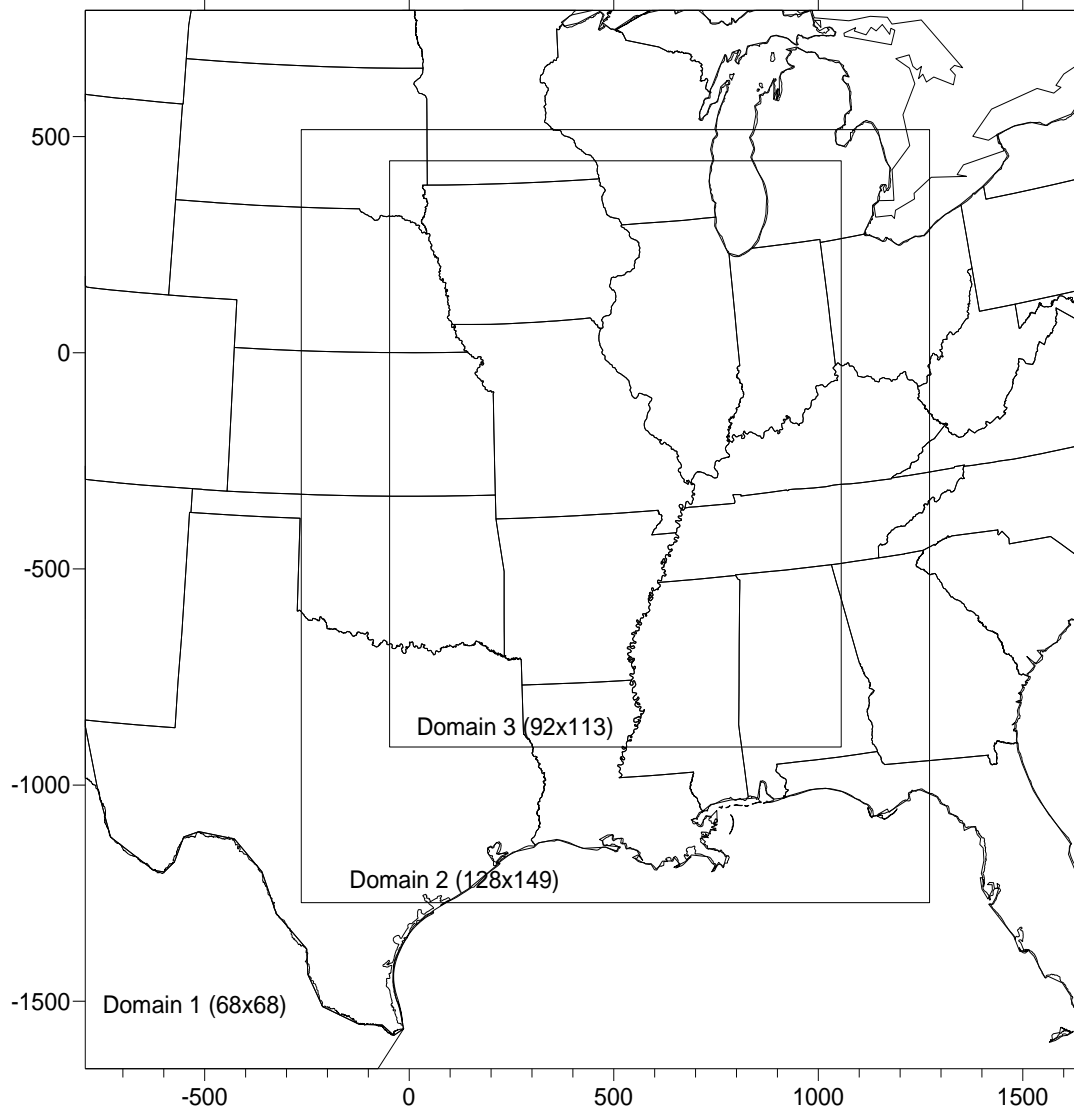
**-design value cannot be calculated until three years data are available

Zn Concentration Difference Time Series: Before and During Facility Idling



Time series for the difference in zinc concentration between the Gateway and Blair stations. Red circles are the observed differences and the black curve is the 15-sample centered moving arithmetic average. Concentration differences outside the axis ranges have been set to the axis limits. The blue line is the steel production from the basic oxygen furnace ("Local Emission Source Contributions to Ambient Fine Particulate Matter in Granite City, Illinois", draft – February 28, 2010, Jay R. Turner, Washington University in St. Louis).

MDNR 36/12 km Regional Modeling



2002 Annual Period

36/12 km MM5, SMOKE,
CMAQ and CAMx modeling

BCs from VISTAS/ASIP
2002, 2009 and 2012
CMAQ simulations

Model Evaluation on
regional (12 km) and local
(urban STN, FRM, StL-SS
sites) scales

*Map graphic and text provided by Ralph
Morris (ENVIRON International
Corporation)*

Annual PM_{2.5} CMAQ Urban/Regional Modeling

Baseyear (2002) Monitored Design Value is **17.5 ug/m³**.

Projected (2009, 2012) Granite City FRM annual PM_{2.5} design values exceeded NAAQS.

Projected 2012 design value for the Granite City monitor is **15.23 ug/m³**. All other monitors demonstrate attainment.

2012 “zero-out” sensitivity test of U.S.Steel: projected design value for Granite City FRM is **13.55 ug/m³** (Same emissions as previous, except zero emissions for USS. Results indicate USS primarily responsible for excess emissions after accounting for regional/local controls.)

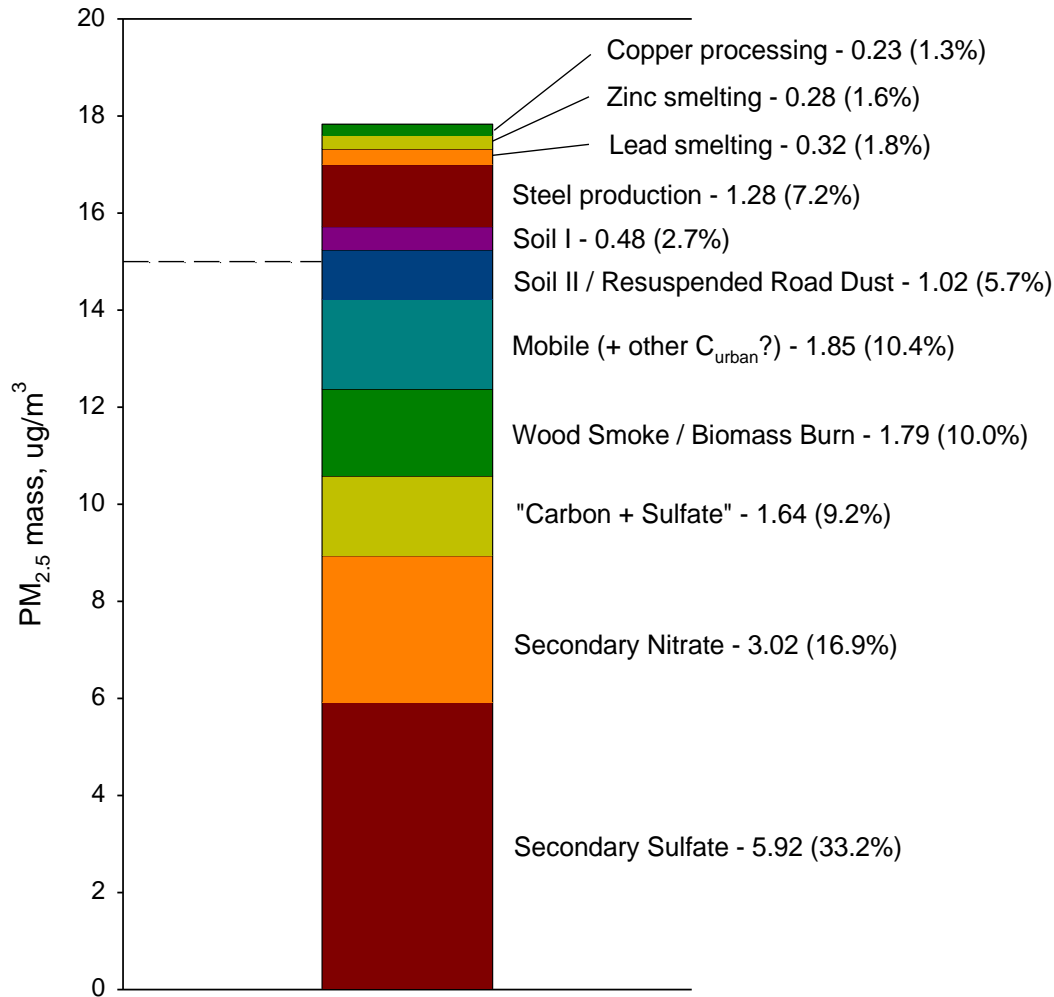
Local Area Analysis

Regional modeling (36/12 km) did not fully “capture” Metro-East $PM_{2.5}$ concentrations (local source contributions). So, implementing “Local Area Analysis” with CMAQ/AERMOD hybrid photochemical grid/steady-state plume modeling system.

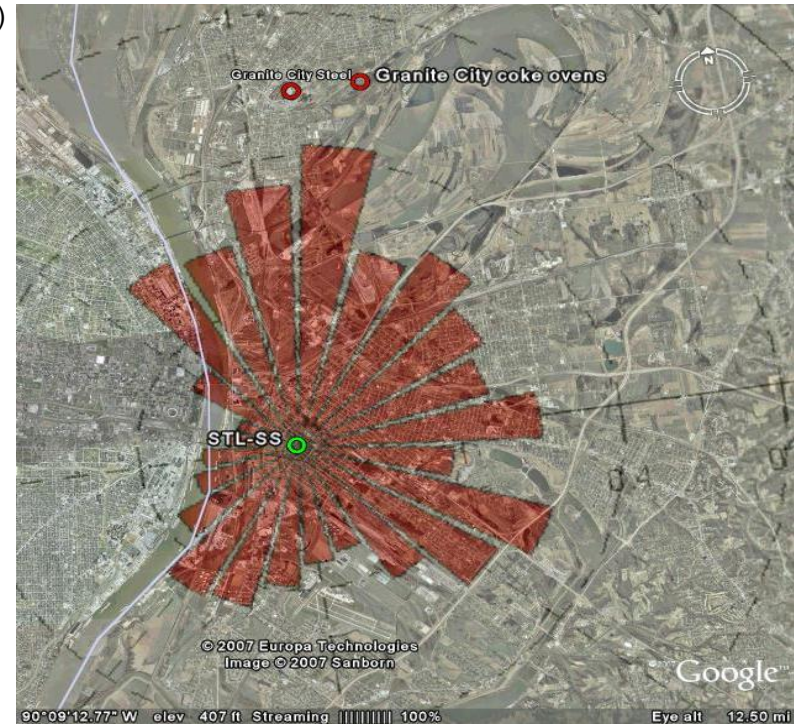
Supplemental CMAQ modeling runs:

1. 2002 base year zero-out: 2 local sources
 2. 2012 base case zero-out: 3 local sources
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Local Sources: Receptor Modeling



PMF Factor Analysis in combination with wind direction data shows large contribution from direction of U.S.Steel – GCW.



Local Source Emissions

- Steel Foundry
- Integrated Iron/Steel Manufacturing Facility w/ By-Product Recovery Coke Batteries
- Heat Recovery Coking Plant (*permitted 2008*)

Summary of Direct PM2.5 Estimated Emissions for 2002 and 2012

<u>Facility</u>	Base Year (2002)		Future Year (2012)	
	<u>(tons/day)</u>	<u>(tons/year)</u>	<u>(tons/day)</u>	<u>(tons/year)</u>
USS-GCW	4.57	1651	4.65	1678
Gateway Energy & Coke	-----	-----	1.17	244
AMSTED Rail Co. Inc.	0.26	66	0.26	66
Total Emissions	4.83	1717	6.08	1988

Facilities and Receptors (AERMOD)



Annual Average Modeled Concentration (2012) and Principal Source Culpability ---FRM Monitor Location (non-final results)

Contribution from all sources: 3.95 ug/m3

U.S. Steel – Granite City Works

Basic Oxygen Furnace (BOF)		Blast Furnace Casthouse	Coke Battery Fugitives	Other
Roof Monitor Fugitives	Vessels - ESP			
1.33 ug/m3	0.35 ug/m3	0.33 ug/m3	0.23 ug/m3	1.21 ug/m3

GECC	ASF-Keystone
0.3 ug/m3	0.2 ug/m3

Relative Response Factors: Example Derivation and Purpose

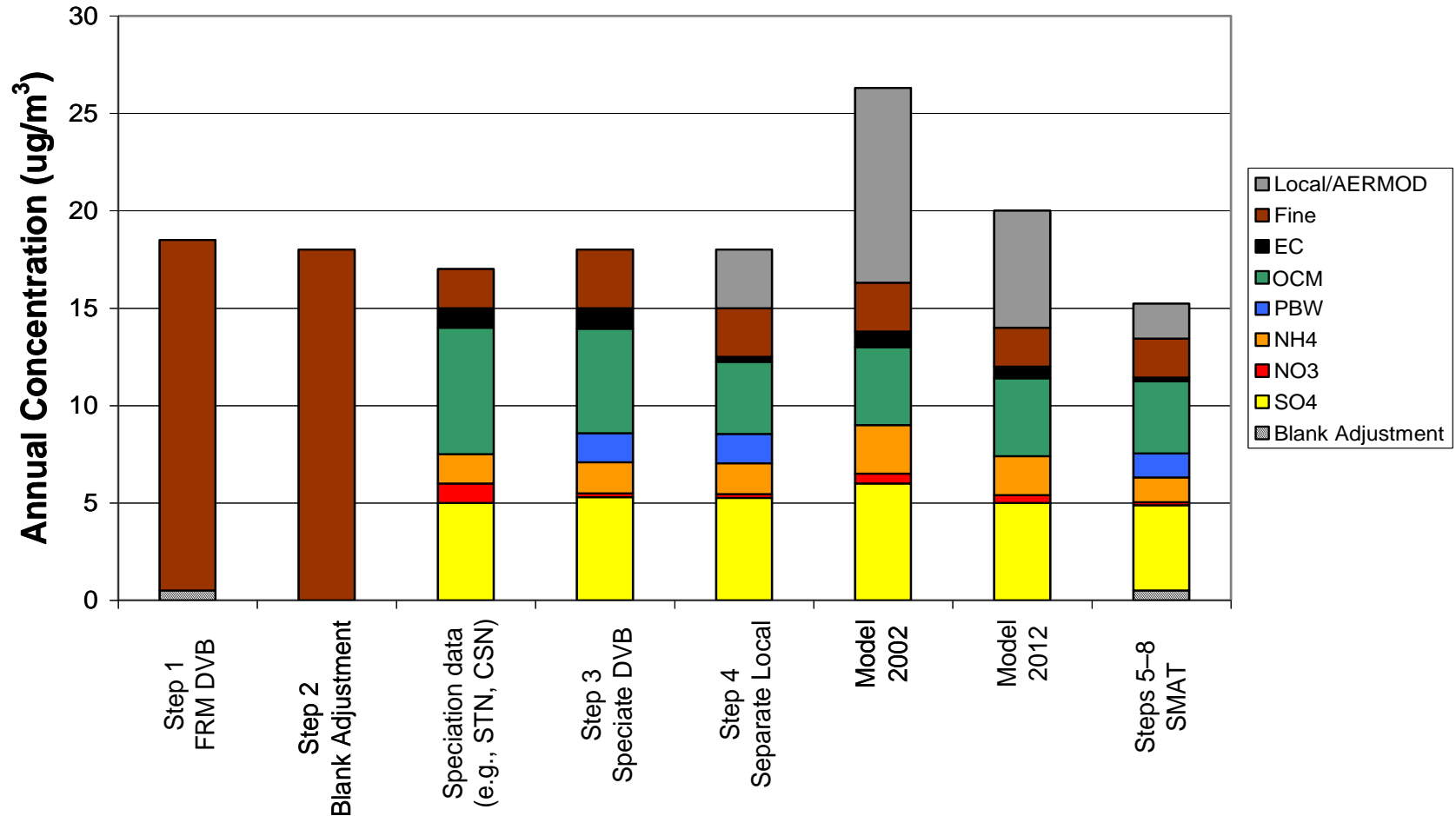
- Base Year FRM Receptor Concentration = 3.39 ug/m^3
- Projected (2012) FRM Receptor Concentration = 3.95 ug/m^3
- Relative Response Factor = $\text{FYRC}/\text{BYRC} = 1.16$
(*FYRC = future year receptor concentration*)
(*BYRC = base year receptor concentration*)
- Project 2012 Design Value through application of:
 $\text{DVF} = \text{DVC} \times \text{RRF}$
(*DVF = future design value; DVC = current design value;*
RRF = relative response factor)

Modeled Attainment Test

Project 2012 PM_{2.5} design value through separate projections of regional and local components and using modeling results in a “relative” sense:

- 1.) $DVF = DVC \times RRF$
 - 2.) Current Design Value (DVC) is separated into local and regional components: $DVC_{local} + DVC_{regional} = DVC$
 - 3.) Project DVC_{local} to DVF_{local} using local source changes--- implemented using AERMOD modeling results
 - 4.) Project $DVC_{regional}$ to $DVF_{regional}$ using regional concentration changes without local contributions---implemented with CMAQ modeling results and the Speciated Modeled Attainment Test (SMAT)
 - 5.) Combine DVF_{local} and $DVF_{regional}$ to get DVF (Future Design Value)
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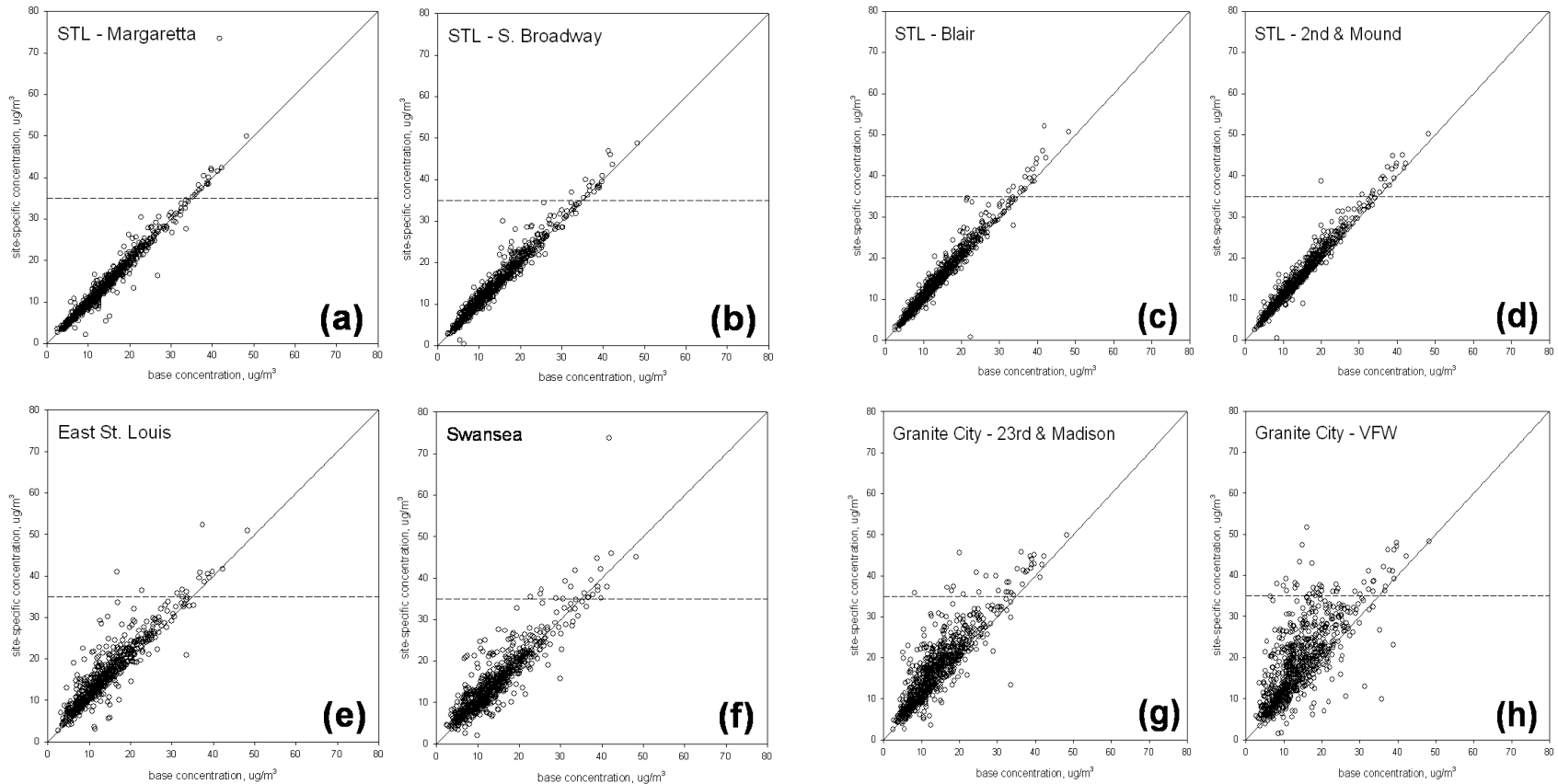
Example Projection Approach



“First Cut” Hybrid Projection Speciated Modeled Attainment Test

	<u>2002 Design Value</u>	<u>2012 Design Value</u>	<u>% Change</u>
<u>“Bottom Line”</u> →	17.27 ug/m ³	16.92 ug/m ³	- 2.0
Local	3.2 ug/m ³	3.68 ug/m ³	+ 15
Regional	13.57 ug/m ³	12.73 ug/m ³	- 6.2
Blank Correction	0.5 ug/m ³	0.5 ug/m ³	0.0
Crustal (regional)	0.73 ug/m ³	0.87 ug/m ³	+ 20
EC (regional)	0.52 ug/m ³	0.37 ug/m ³	- 28
OCM (regional)	6.19 ug/m ³	6.46 ug/m ³	+ 4
SO4 (regional)	3.10 ug/m ³	2.45 ug/m ³	- 21
NO3 (regional)	0.84 ug/m ³	0.71 ug/m ³	- 15
NH4 (regional)	1.22 ug/m ³	1.10 ug/m ³	- 10
PBW (regional)	0.99 ug/m ³	0.77 ug/m ³	- 22

Daily Average PM_{2.5} Mass Concentration vs. Area Wide Base Concentration



Daily-average PM_{2.5} mass concentration versus the area-wide base concentration at eight compliance monitoring stations in the St. Louis area: Missouri sites (top row) and Illinois sites (bottom row) [“Local Emission Source Contributions to Ambient Fine Particulate Matter in Granite City, Illinois”, draft – February 28, 2010, Jay R. Turner, Washington University in St.Louis]

Mean excess mass concentrations (2002) at the Granite City monitor: Granite City – Area-wide base concentration = 2.8 ug/m³; Granite City – Margareta Street = 3.2 ug/m³; Granite City – Blair Street = 2.2 ug/m³.

Quarterly RRF Values for Regional and Local Components

			Q1	Q2	Q3	Q4
Regional RRF	CMAQ (3x3)	SO4	0.980	0.776	0.651	0.895
		NO3	0.775	0.293	0.273	0.690
		NH4	0.872	0.631	0.584	0.788
		OCM	0.979	0.981	0.982	0.990
		EC	0.664	0.662	0.663	0.639
		Crustal	1.089	1.128	1.155	1.102
Local RRF	AERMOD (9x9)	PM _{2.5}	0.958	0.994	0.974	0.942
	AERMOD (5x5)	PM _{2.5}	0.956	0.989	0.969	0.926

2012 PM_{2.5} DVF Projections

		3.2 µg/m ³ of local contribution				
		2002 DVC	9x9 AERMOD receptors		5x5 AERMOD receptors	
			2012 DVF	% change	2012 DVF	% change
Regional	Crustal	0.41	0.46	10.6%	0.46	10.6%
	EC	0.82	0.53	-34.5%	0.53	-34.5%
	OCM	4.68	4.60	-1.7%	4.60	-1.7%
	SO ₄	3.70	2.93	-20.8%	2.93	-20.8%
	NO ₃	1.34	1.00	-25.0%	1.00	-25.0%
	NH ₄	1.49	1.10	-26.7%	1.10	-26.7%
	PBW	1.13	0.73	-35.6%	0.73	-35.6%
Local	PM _{2.5}	3.20	3.09	-3.3%	3.07	-4.1%
Blank adjustment		0.50	0.50	0.0%	0.50	0.0%
Total		17.27	14.95	-13.5%	14.92	-13.6%
		2.2 µg/m ³ of local contribution				
		2002 DVC	9x9 AERMOD receptors		5x5 AERMOD receptors	
			2012 DVF	% change	2012 DVF	% change
Regional	Crustal	0.41	0.46	10.6%	0.46	10.6%
	EC	0.82	0.53	-34.5%	0.53	-34.5%
	OCM	5.68	5.59	-1.7%	5.59	-1.7%
	SO ₄	3.70	2.93	-20.8%	2.93	-20.8%
	NO ₃	1.34	1.00	-25.0%	1.00	-25.0%
	NH ₄	1.49	1.10	-26.7%	1.10	-26.7%
	PBW	1.13	0.73	-35.6%	0.73	-35.6%
Local	PM _{2.5}	2.20	2.12	-3.5%	2.11	-4.3%
Blank adjustment		0.50	0.50	0.0%	0.50	0.0%
Total		17.27	14.96	-13.4%	14.94	-13.5%

Proposed U.S. Steel BOF Rulemaking

- IEPA produced internal draft rule to require MACT standards for new BOF sources under final NESHAP (Integrated Iron & Steel Manufacturing Facilities – 2003, amended 2006) be applicable to the existing USS-GCW BOF Shop.
 - On/after January 1, 2012:
 - All BOF PM emiss's ducted to control equip.
 - Uncaptured emissions from any BOF shop opening must not exceed 10% opacity.
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Proposed U.S. Steel BOF Rulemaking (cont.)

--PM emiss's from control equipment:

* ≤ 0.01 gr/dscf (in operation before 1/1/2010)

* ≤ 0.0052 gr/dscf (start-up after 1/1/2010)

*Average opacity $\leq 10\%$

--Hot metal transfer, desulfurization, skimming, and ladle lancing PM emiss's ≤ 0.003 gr/dscf

--Ladle metallurgy PM emiss's ≤ 0.004 gr/dscf

--Equip. inspections, monitoring systems, opacity observations, recordkeeping, reporting, etc.

Memorandum of Understanding

- Enhanced operational monitoring for the BOF capture systems (within 2 months) and new control systems (within 3 months of start-up). Opacity readings on openings in the BOPF building (within two months).
 - PM emission limits (January 1, 2012): 0.01 gr/dscf (BOP ESP stack), 0.005 gr/dscf (hot metal desulfurization/reladling, slag skimming, ladle metallurgy baghouse stacks; also for new tapping baghouse by March 31, 2013)
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Memorandum of Understanding (cont.)

- Submit an application for a federally enforceable permit(s) to incorporate the prior requirements (within 2 months).
 - Installation/operation of steam rings for oxygen lances (BOP shop) by October 31, 2011, barring appeal of the construction permit.
 - Evaluation (and implementation?) of potential upgrade to BOF charging control system (within 9 months).
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