

Improving Ozone Model Performance in Denver and Beyond

Local Government Coalition

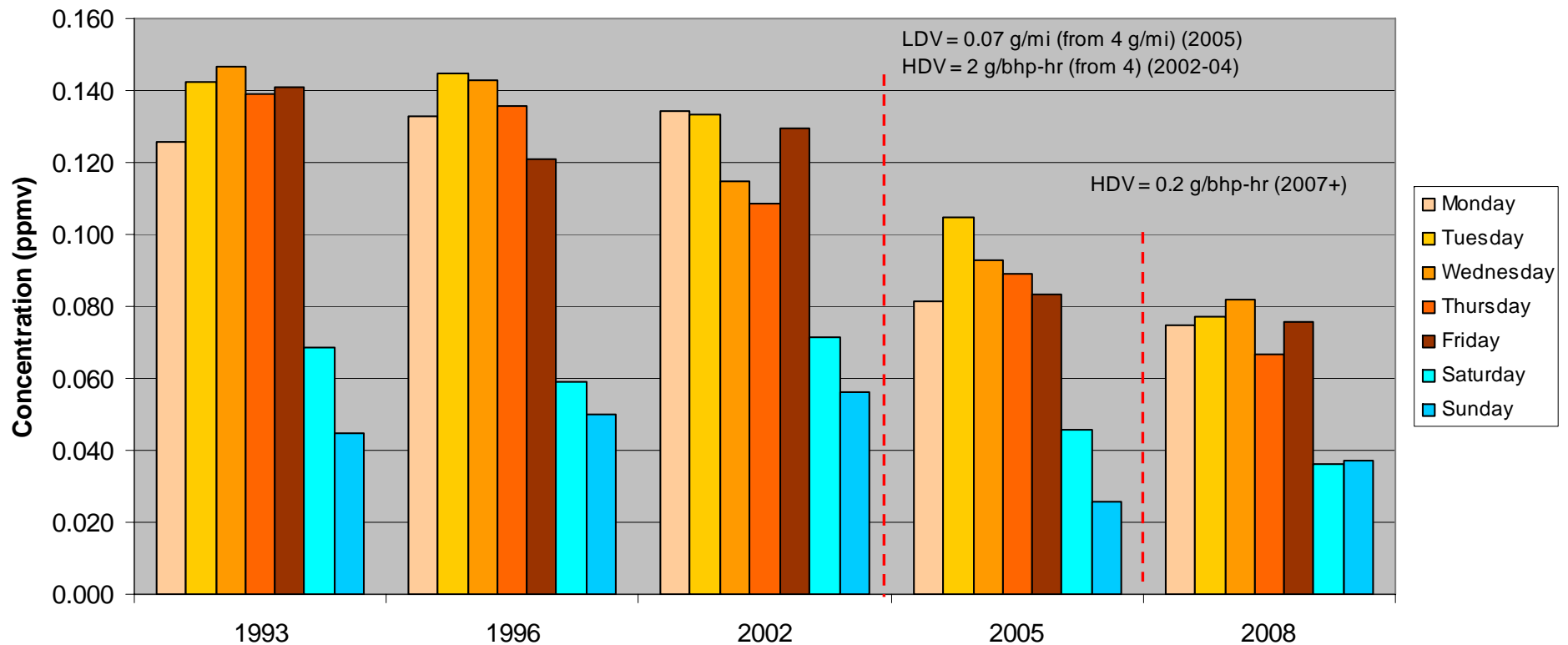
February 2009

Overview

- Ambient Monitoring Trends in Denver
- Emissions Inventories – Are They Adequate?
 - Especially on-road mobile
 - How do they compare with ambient data?
 - Cumulative Assessment of Real world Data: Reasonable Observations for Validation of Emissions (CARL ROVE method)
- 2006/2015/2020 Scope of Work
 - Focus on high ozone episodes within Jun-Jul 2006 period

NOx Trends in Denver

CAMP 6-9am Ambient NOx Trends May-Aug by DOW and Year; dominant influence from on-road mobile



EPA MOBILE 6.2: 29% reduction of NOx in Denver County 1996-2005

Ambient Data: 34% reduction

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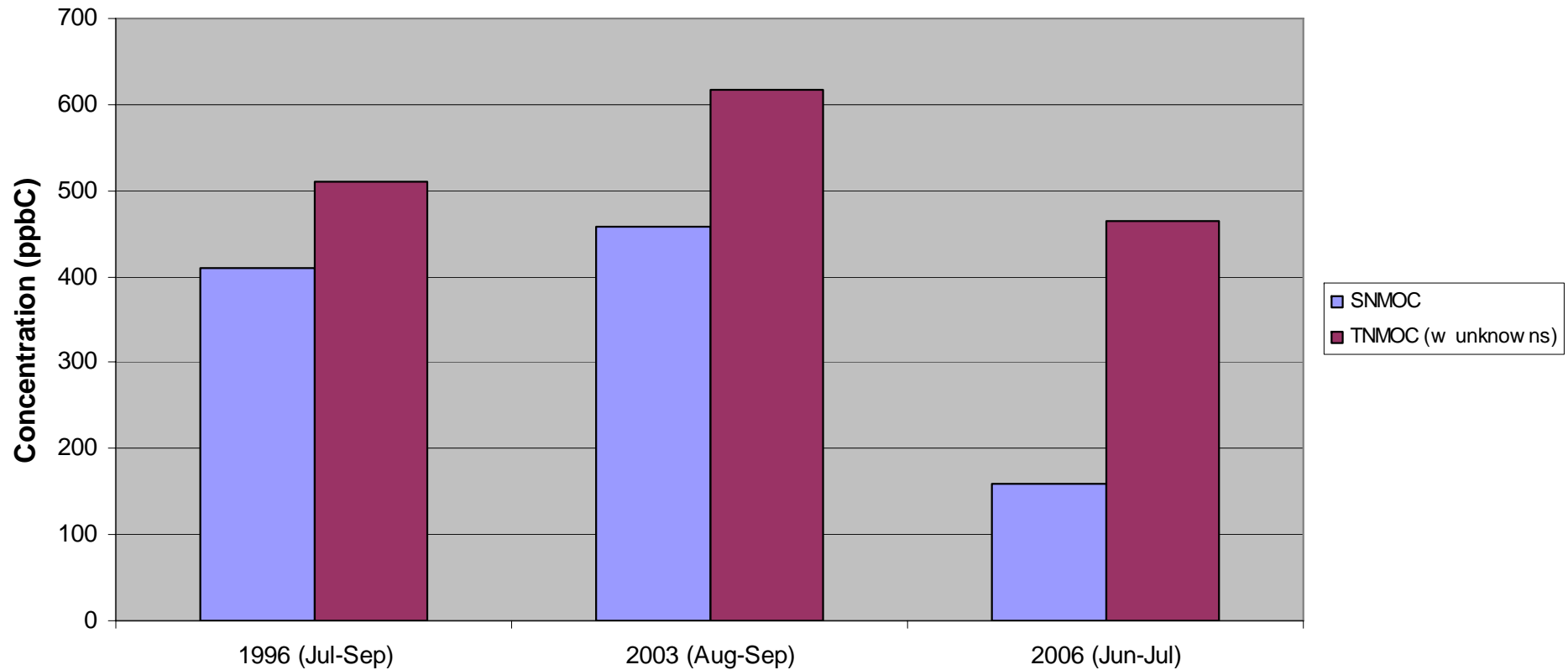
Remote Sensing: 40% reduction

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1997-2005

VOC Trends in Denver

CAMP 6-9am SNMOC and TNMOC 1996-2005



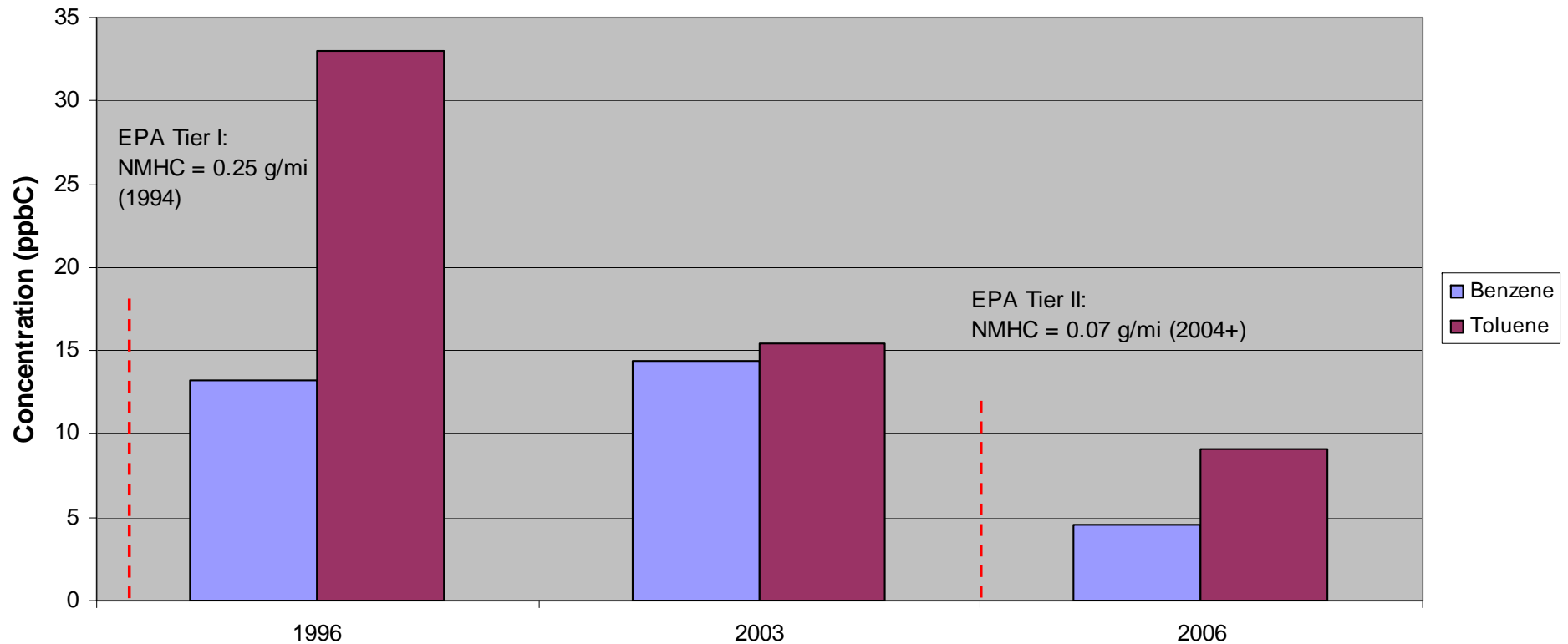
EPA MOBILE 6.2: 50% reduction of SNMOC in Denver County 1996-2005

Ambient SNMOC: 61% reduction " " 1996-2006

Remote Sensing: 69% reduction " " 1997-2005

Air Toxics Trends in Denver

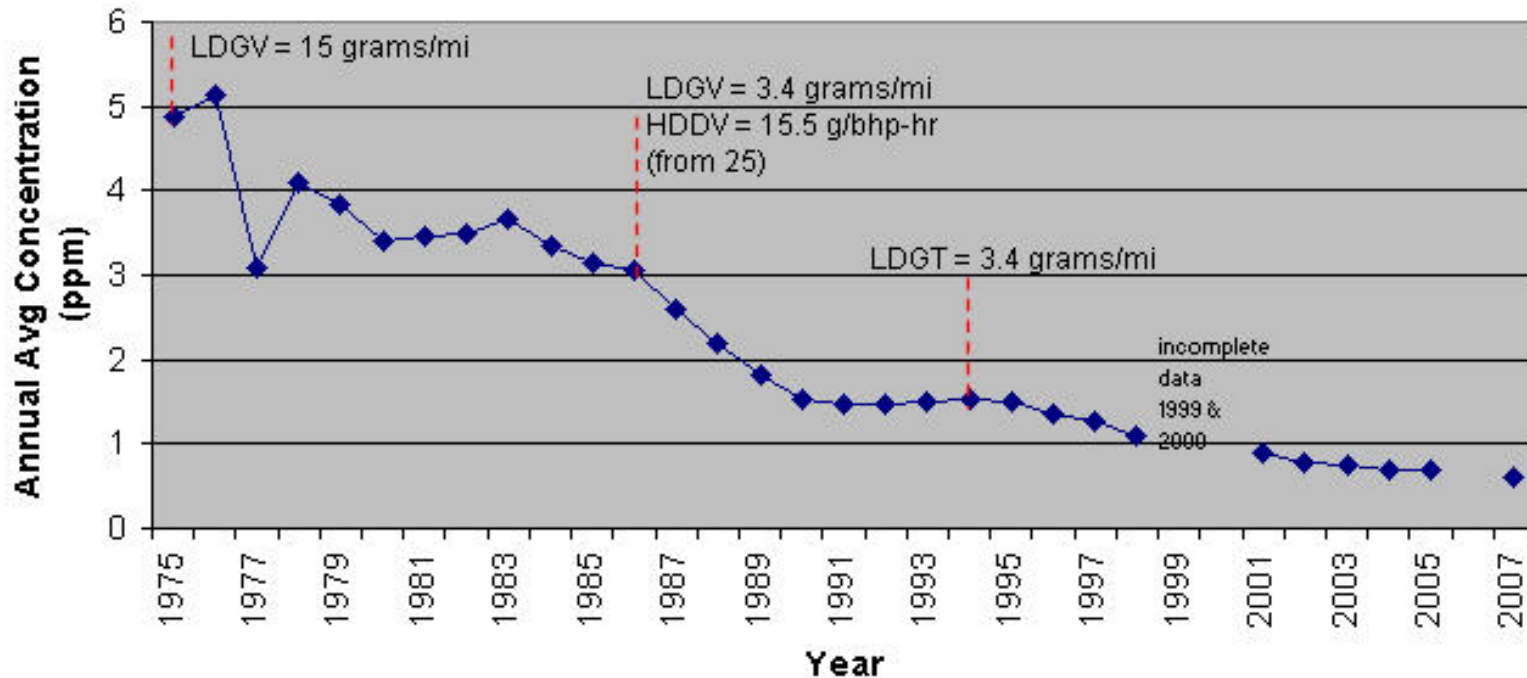
CAMP 6-9am Benzene and Toluene Trends 1996-2006



EPA MOBILE 6.2: 49% and 47% reduction of Benzene and Toluene 1996-2005
 Ambient Data: 66% and 72% reduction " " 1996-2006

Carbon Monoxide Trends in Denver

CAMP Annual Average CO Trends 1975-2007
w/EPA Emissions Stds Milestones



EPA MOBILE 6.2: 31% reduction of Carbon Monoxide 1996-2005
 Ambient Data: 50% reduction " " 1996-2005

Emissions Inventory Validation

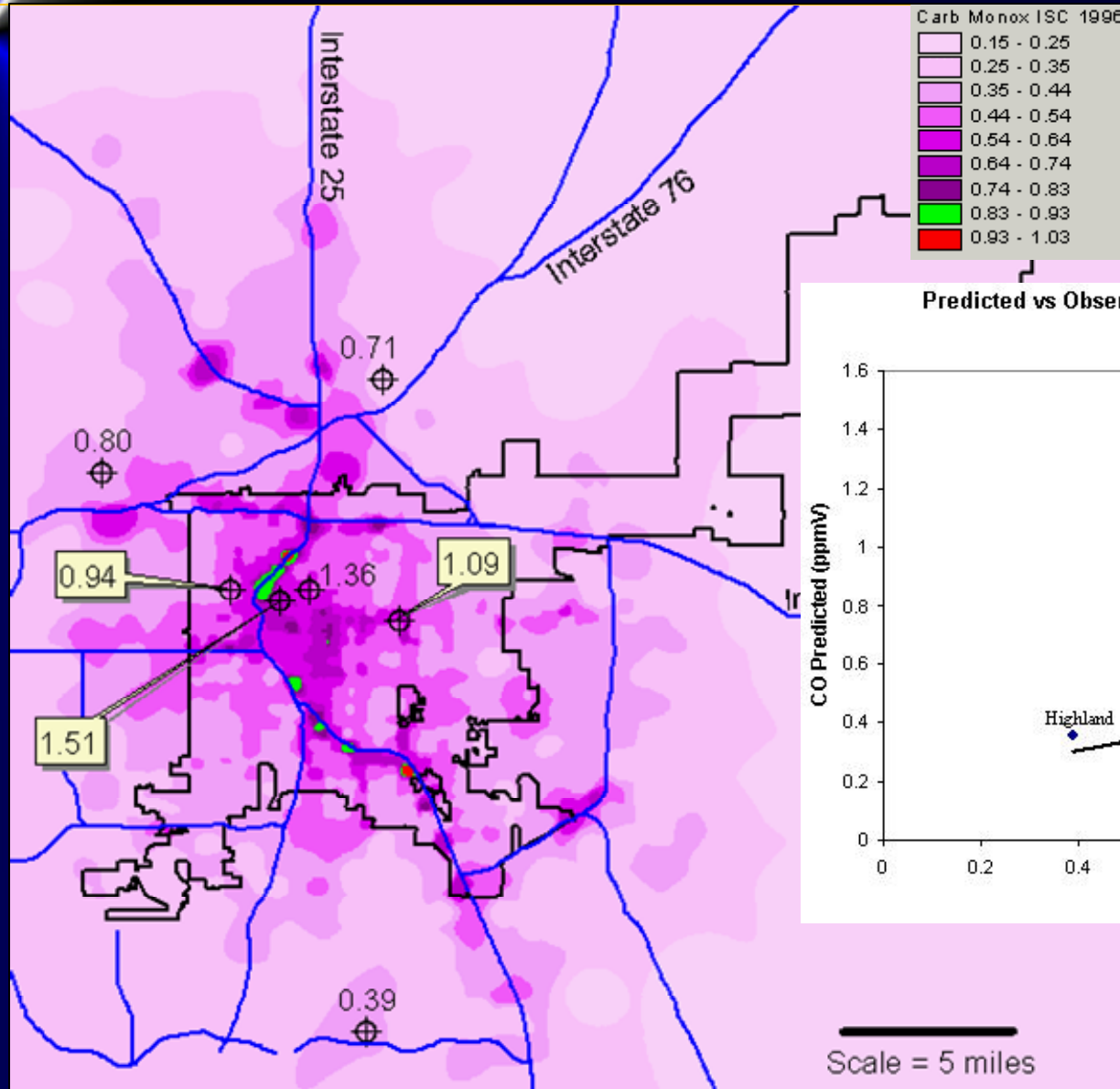
- Trends seem to agree, but what about total emissions?
 - Onroad VOCs underestimated by a factor of 2 or 3??
- EPA MOBILE6.2 (top down) versus fuel-based inventory (bottom up).
 - Fuel sales data assumed to be more accurate (tax \$\$)
 - Apportioned to metro area using Metro VMT/State VMT fraction and population (~50%)
 - Combined with DU remote sensing derived emissions factors
- 1996 was a good year for such comparisons
 - NFRAQS study: local FTP (dynamometer) and IM240 testing for cross section of LDVs during winter and summer (gas, diesel, smokers)

Top Down vs Bottom Up Inventories (1996)

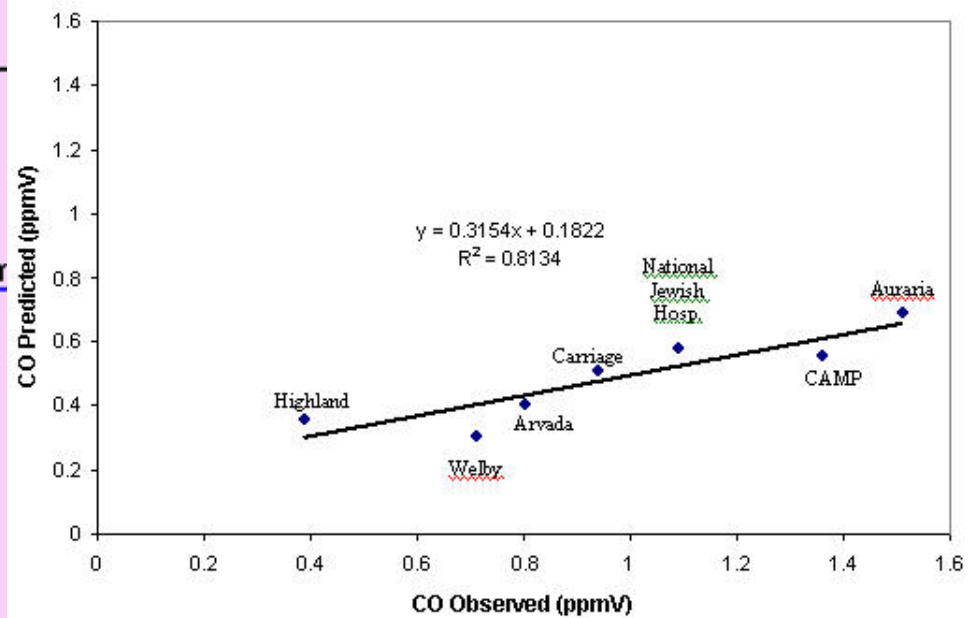
Tailpipe Emissions	Emissions (tons/year)			
	Benzene	VOC	NO(x)	CO
MOBILE6.2 Total (EPA starts & dist)	1700	36,500	45,698	597,000
MOBILE6.2 Total (DRCOG starts & dist)	1300	26,849	45,698	456,000
MOBILE6.2 Hot Stabilized (either)	--	14,700	--	268,000
NFRAQS FTP	1465	29,500	--	315,500
NFRAQS IM240	--	18,400	--	231,000
Fuel Based	1371 ± 21%	31,000	45,625	246,500

- Tailpipe benzene was $\pm 20\%$ for all methods
- Tailpipe Total VOC is 20% higher from MOBILE6.2
 - Starts per day per DRCOG (4) are $\frac{1}{2}$ the EPA default (8)
 - MOBILE6.2 “hot stabilized” emissions more comparable with Fuel Based or IM240 inventories
- Tailpipe CO (MOBILE 6.2 hot stabilized) within 15% of either alternative inventory
 - MOBILE6.2 Total CO (EPA starts) over predicts FTP emissions by ~ 2
- MOBILE6.2 NOx same as fuel based

Modeling: How We Compare Emissions w/ Ambient Data



Predicted vs Observed Carbon Monoxide Concentrations (ppmV)



How Does the Denver NAA Compare to Other NAAs?

Source Category	Recent SIP Emissions Inventories (tons per day, tpd)									
	2005 SoCAB (CA)			2005 Dallas Ft Worth			2006 Denver			
	VOC	NOx	CO	VOC	NOx	CO	VOC	NOx	CO	
Area + Point (CA only)				255	52	91	227	60	-	O&G
Point	267	95	171	32	56	34	43	107	-	
Nonroad	175	358	986	67	106	748	70	94	-	
Onroad	298	576	2979	133	340	1686	106	167	-	
Biogenic	-	-	-	642	52	-				
Total Anthro	740	1029	4136	486	554	2560	445	428	-	
Area (sq mi)	6000			5000			3500	2005 DRCOG NAA area		
Population	1.69E+07			6.10E+06			2.70E+06	2005		
VMT (mi/day)	3.9E+08			1.7E+08			6.8E+07			
VOC+NOx tpd/sq mi	0.29			0.14			0.25			
VOC+NOx tpd/person	1.05E-04			1.1E-04			3.2E-04			

- Denver emissions density (tpd/sq mi or per capita) greater than DFW despite 2.5x less VMT and less than half the population

Photochemical Modeling Next Steps

- Phase I scope is reasonable and necessary
 - Task 2: Plume in grid recommended to see how point sources affect ozone
 - Task 8: sensitivity scenarios could test “carrying capacity” concept
- Phase II
 - While all would be nice, all are not necessary
 - YES:
 - Task 13 - MM5 nudging, especially for two July episodes, diurnal evaluation
 - All emissions inventory update/projection tasks are high priority
 - NFRCOG VMT data
 - NO/MAYBE:
 - Task 12 - existing air toxics MOBILE6.2 speciation could be compared with Smoke processed outputs
 - Alternate met (WRF) and ozone model (CMAQ) might provide useful comparisons, but seems more pertinent to next SIP and not for evaluation of NOx control strategies.

Trends in Ozone Exceedance Days

	# Days 8-hr O3 >= 80 ppb		# Days 8-hr O3 >= 90 ppb	
	NREL	Rocky Flats	NREL	Rocky Flats
1993	n/a	6	n/a	1
1994	4	3	0	0
1995	3	3	0	0
1996	5	6	0	0
1997	2	1	0	0
1998	13	9	6	5
1999	5	4	0	1
2000	9	4	0	0
2001	4	7	1	0
2002	5	11	3	1
2003	16	21	7	7
2004	0	0	0	0
2005	3	2	0	0
2006	7	11	1	4
2007	8	10	1	4

- Is reduced NO_x the cause for increasing double digit exceedance days at Rocky since 2000?
- Not likely, as 2002 ambient summer NO_x was unchanged from 1996
- Weather (as always) the likely culprit

Conclusions/Recommendations

- Trends
 - NO_x: Predicted and ambient trends compare well
 - VOC: MOBILE6.2 trends also compare within 25% of ambient
 - Toxics: MOBILE6.2 trends within 30% of ambient
- Emissions Totals
 - Tailpipe benzene, VOC, CO (hot running), NO_x, all within $\pm 20\%$ of alternative methods
 - No valid reason to double or triple onroad VOC emissions
 - Some tweaks to emissions models should be explored (for CO)
- Let's collaborate on a Front Range Air Quality Study for 2010.
 - Multi-stakeholder planning process
 - Grant and private \$
 - Build on existing work and collaboration
 - In preparation for next SIP