Ozone in Denver

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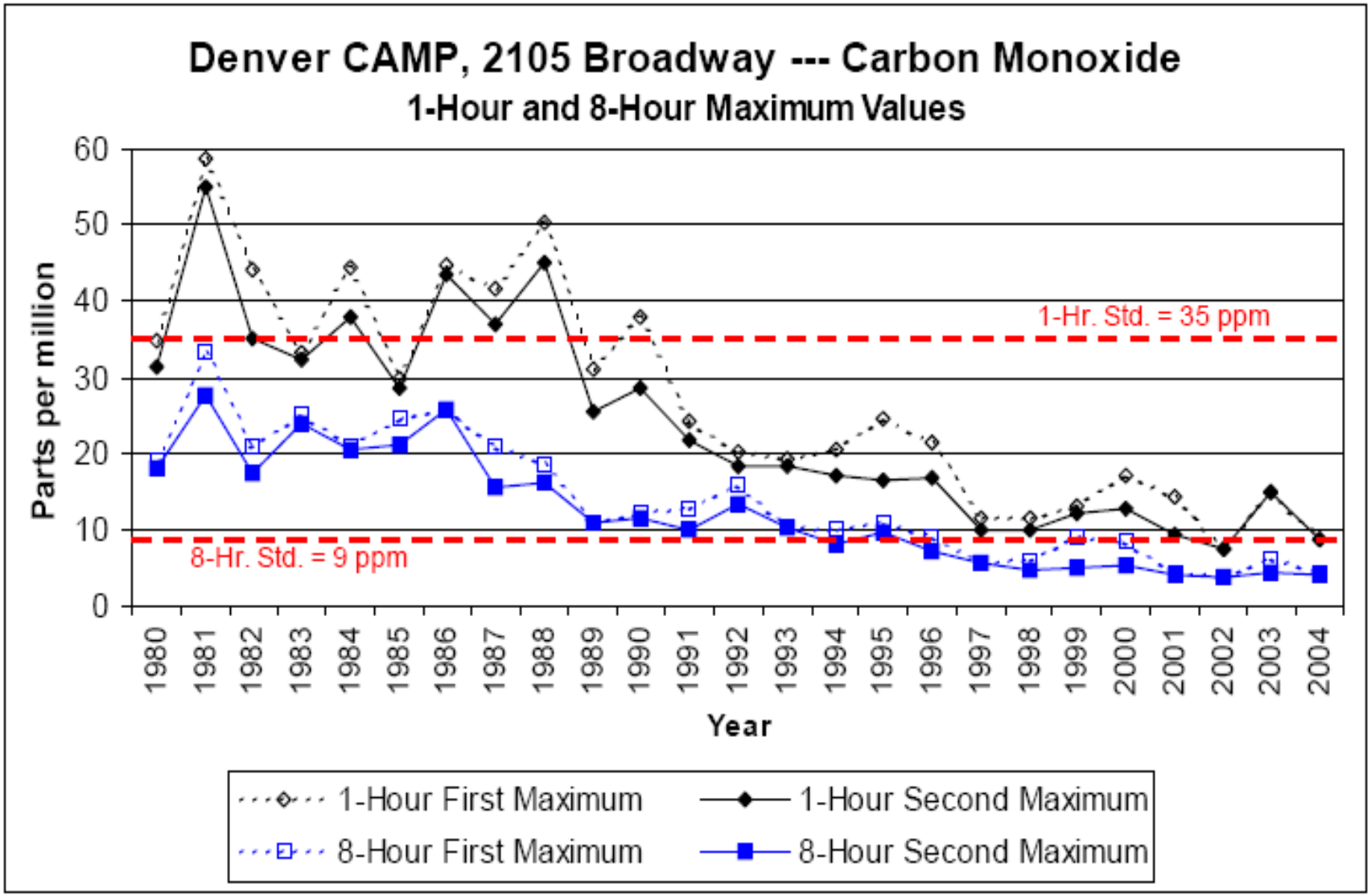
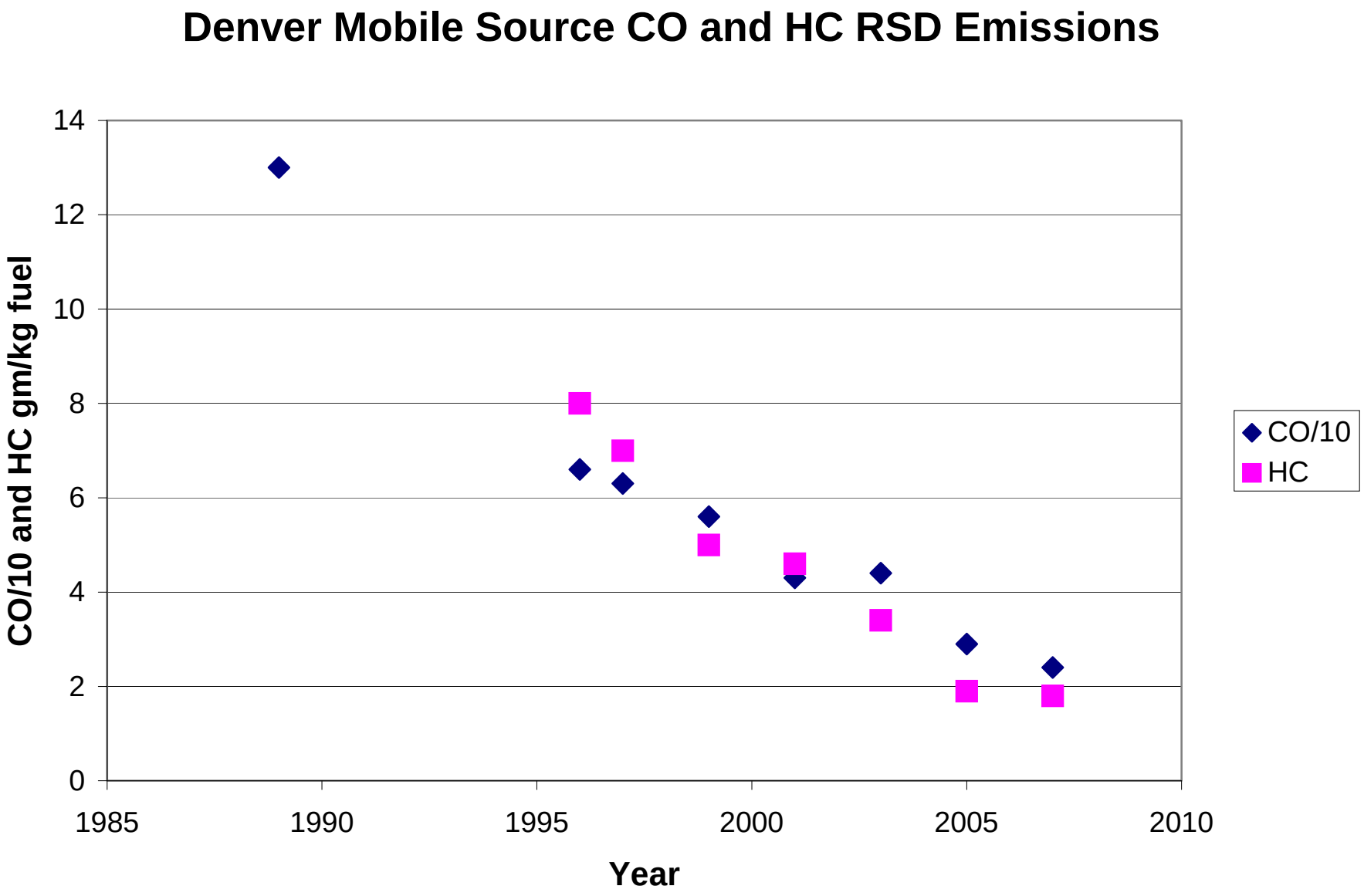
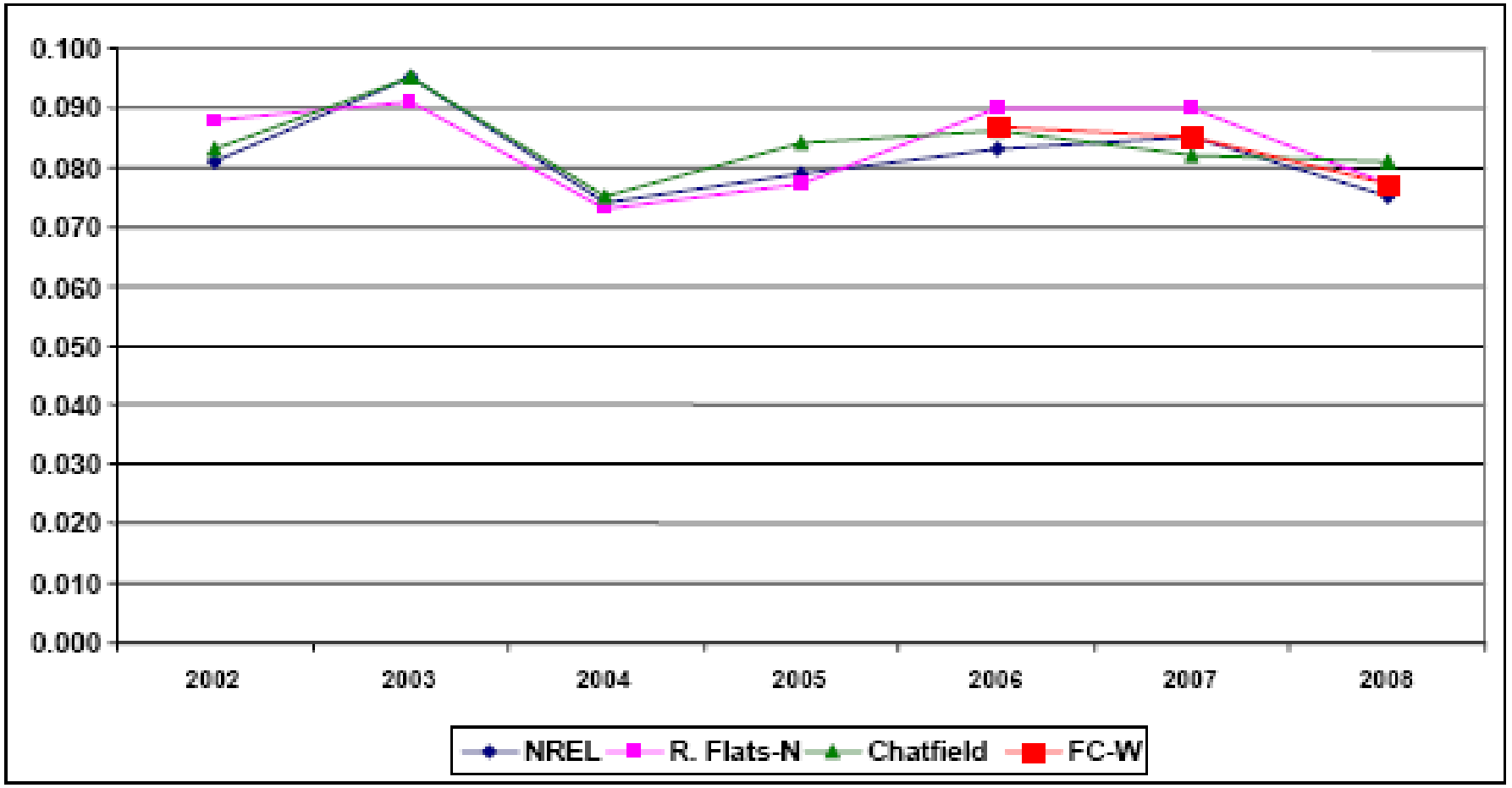

Denver CAMP, 2105 Broadway --- Carbon Monoxide
1-Hour and 8-Hour Maximum Values
Parts per million
60
50
40
30
20
10
0
1-Hr. Std. = 35 ppm
8-Hr. Std. = 9 ppm
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Year
1-Hour First Maximum
1-Hour Second Maximum
8-Hour First Maximum
8-Hour Second Maximum


Denver Mobile Source CO and HC RSD Emissions
CO/10 and HC gm/kg fuel
14
12
10
8
6
4
2
0
1985
1990
1995
2000
2005
2010
Year
CO/10
HC

We are doing one thing RIGHT!

Chart 1: Time Series of Monitored 4th Maximum 8-Hour Ozone Values (ppm)



We are doing some things WRONG!

NOx or VOC limited

- Ozone photochemistry is complicated.
- The ingredients are NOx VOC and sunlight.
- I have published a simplified model showing why VOC control is always beneficial; NOx control most often is not.
- If VOC limited, NOx reduction makes things worse not better.

Assessment of the ozone-nitrogen oxide-VOC sensitivity of Mexico City...

- R. Torres-Jardon et al. JAWMA ***59***, 1155-1172, October 2009.
- "We conclude that future ozone control plans with particular emphasis on NO_x reductions may not be the optimum strategy for the MCMA."

Broken cars, fuels and inventories
OZONE EAC Presentation
www.feat.biochem.du.edu

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I told them

- If you leave summer ethanol in with a 1 lb waiver you will violate the 85 ppb standard.
- If you do not fix the I/M program you will violate the 85 ppb standard.
- Do not believe the computer model results which predict that you will not.

Should we trust the model output or the ambient data?

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- EAC used the same model that we are now using to predict that we would not violate. 2007 AND 2008 data proved it WRONG.
- D. McNally noted Aug. 11 2008 that model outputs are only as good as the inputs - meteorology and inventory. He showed 11 comparisons to real past data for two chosen days.
- The model underpredicted the range of the data by 275% (expected)*
- The model underpredicted the observed peaks by an average of 7 ppb.
- The model underpredicted day1-day 2 variation by 200%. The RMNP comparison was not shown. In that case the model prediction was a +4 ppb ozone increase. The observation was a -17 ppb DECREASE.
- Suggested improvement. Triple the on-road HC emissions and divide the off-road CO emissions by the same factor.

*Maryland 2007 SIP Chapter 10 p 30. “CMAQ underpredicts daily ozone variability…”

Broken cars

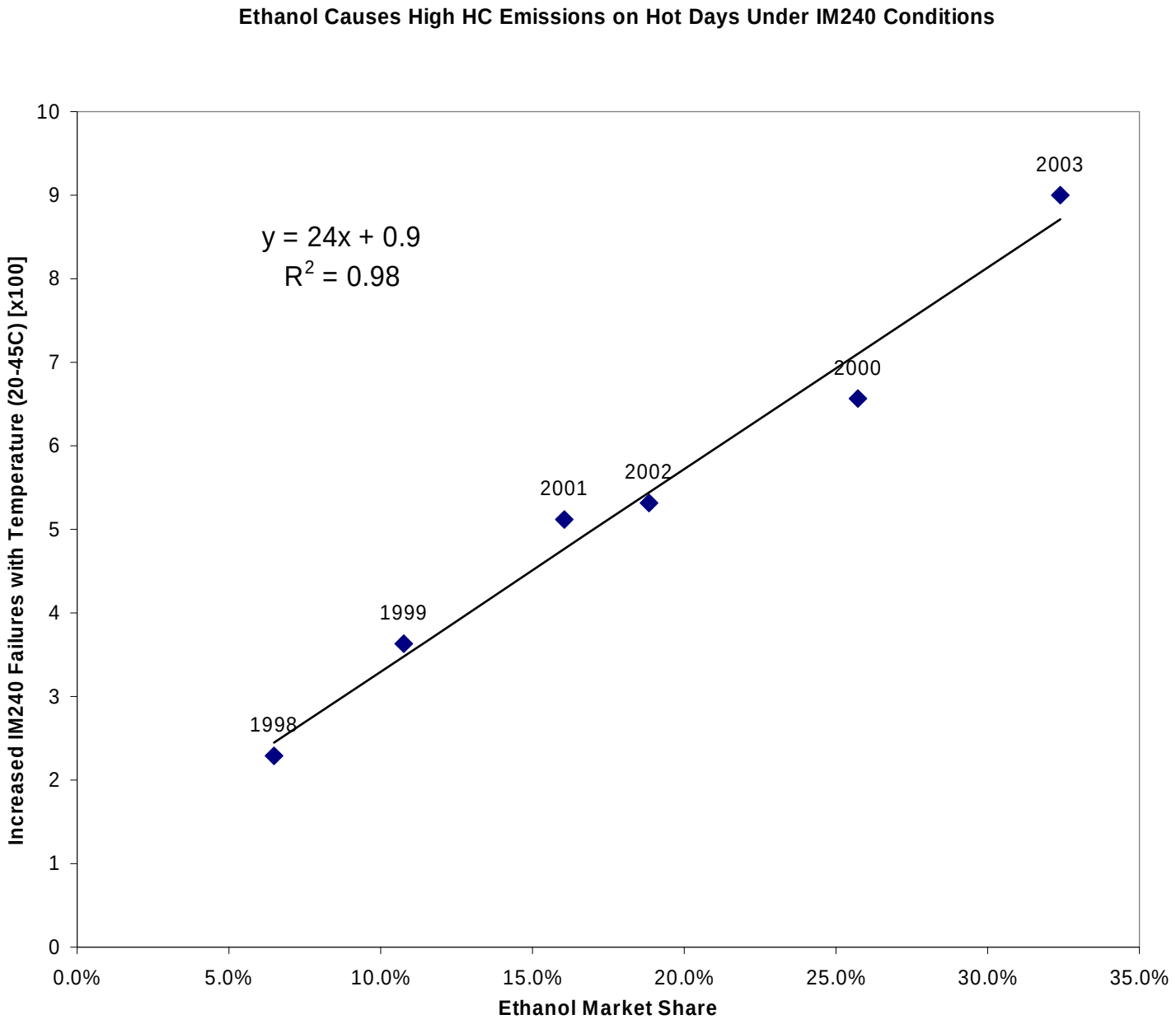
- Each day of on-road readings at Speer and I-25 we find about three cars emitting an average of 50 gm/mile HC.
- The new car standard is 0.04 gm/mile.
- The vehicle owners are unlikely to be recruited into voluntary government run programs.

Broken Cars

- Scofflaws
  - Tighten I/M enforcement
  - Cut points won't help, they only find more marginal emitters
  - OBDII won't help either
  - They are easy to find with remote sensing

Broken Fuels

- High temperature effects are not in any model and are critically important to Denver's ozone problem.
- They can be studied by looking at available data.


Ethanol Causes High HC Emissions on Hot Days Under IM240 Conditions
y = 24x + 0.9
R2 = 0.98
1998
1999
2001
2002
2000
2003
Increased IM240 Failures with Temperature (20-45C) [x100]
Ethanol Market Share
0
1
2
3
4
5
6
7
8
9
10
0.0%
5.0%
10.0%
15.0%
20.0%
25.0%
30.0%
35.0%

Thanks to

- ESP, NSF, CRC, RAQC, CARB, BAR, NREL, API, Shell, USAID, EPA, RAC, Air Care Colorado, SCAQMD, Unocal, Colorado Office of Energy Conservation, Ken Barr, U. of Denver, Illinois DNR, others that I may have missed.
- Gary and Annette Bishop and countless Graduate Students and research assistants.