MOBILE6 Validation Studies

Presented by

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Presentation Overview

- Purpose and project overview
- Tunnel study comparisons
- Heavy-duty chassis data comparisons
- Work in progress

MOBILE6 Model Evaluation Project: Purpose

- To conduct top-down assessments of MOBILE6 emission factors using “real-world” data
- To use available data on vehicle emissions collected in a controlled manner such that the vehicle sources are well-characterized and can be attributed to a test fleet that can be reasonably duplicated using MOBILE6.

MOBILE6 Model Evaluation Project

- Task 1: Analysis of tunnel studies
- Task 2: Ambient Ratio Analyses
- Task 3: Other validation approaches
  - 3.1: Comparison of the MOBILE6 heavy-duty diesel emission rates to heavy-duty chassis dynamometer measurements
  - 3.2: Comparison of emissions distributions from remote sensing to MOBILE6 predictions
  - 3.3: Evaluation against fuel-based emissions for diesel vehicles
- Task 4: EIIP guidance document preparation

Tunnel Study Comparisons: Purpose

- Use emission factors derived from tunnel studies to evaluate MOBILE6 model performance under a range of operating conditions
- Compare to previous MOBILE versions' performance under the same conditions to assess the effects of model updates

Tunnel Study Comparisons: Approach

- Compare light-duty (LD), heavy-duty (HD) and emission factors fleet-average
- Where LD or HD emission factors were not specifically derived in the original study, a regression of fleet-average emission factors and fleet mix was used to extract vehicle class-specific factor
- Experimental runs were modeled using hourly temperatures to make full use of MOBILE6 air conditioning effects
- Refueling, diurnal, and start emissions were excluded (i.e., it was assumed that all vehicles are in hot stabilized mode)

Tunnel Study Comparisons: Issues/Caveats

- Effects of grades are not modeled by MOBILE6
- Heavy-duty diesel NOx defeat device operation difficult to determine (implicitly assumed in MOBILE6 for applicable model years)

Tunnel Studies Used

Tunnel	Location	Length (m)	Fleet
Fort McHenry	Baltimore, MD	2174	Highway
Tuscarora Mountain	Pennsylvania Turnpike, PA	1623	Highway
Callahan Connector	Boston, MA	1545	Urban
Caldecott	S.F. Bay Area, CA	1100-1149	Highway

Tunnel	Year of Study	Fleet-Avg	LD	HD
Fort McHenry	1992(s)	X	x	x
Tuscarora	1992(s), 1999(s)	x	x	x
Callahan	1995(s)	x		
Caldecott*	1997(s)			x

(s) = summer season

* comparison with CA data requires adjustment to model outputs to account for differences in certification standards

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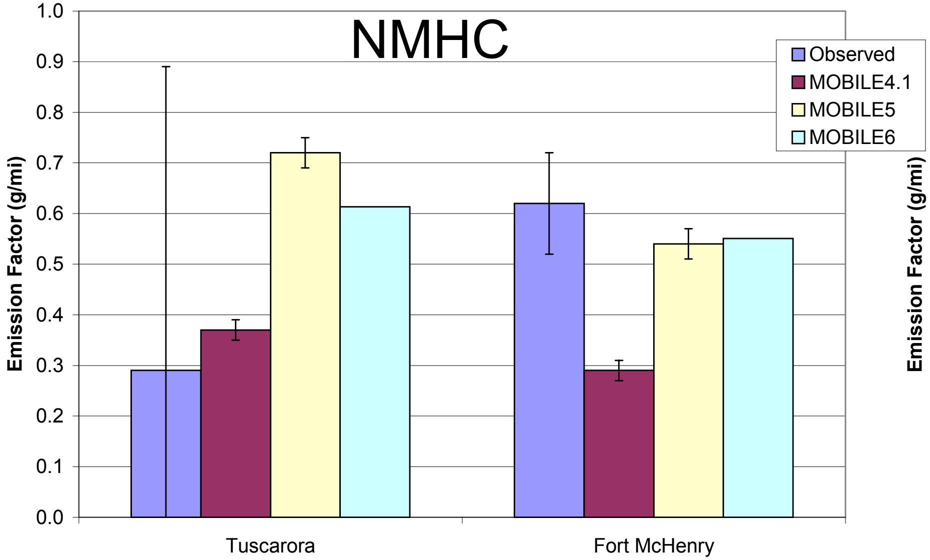
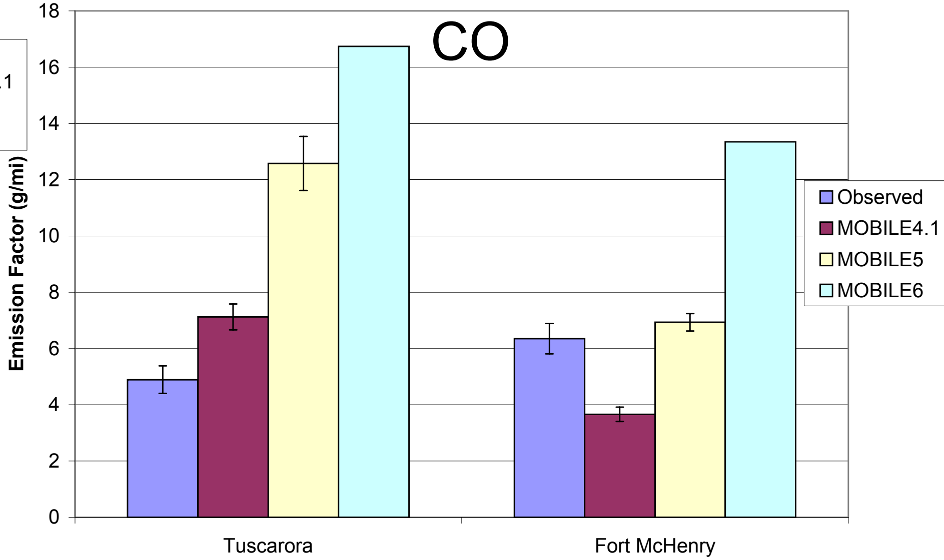
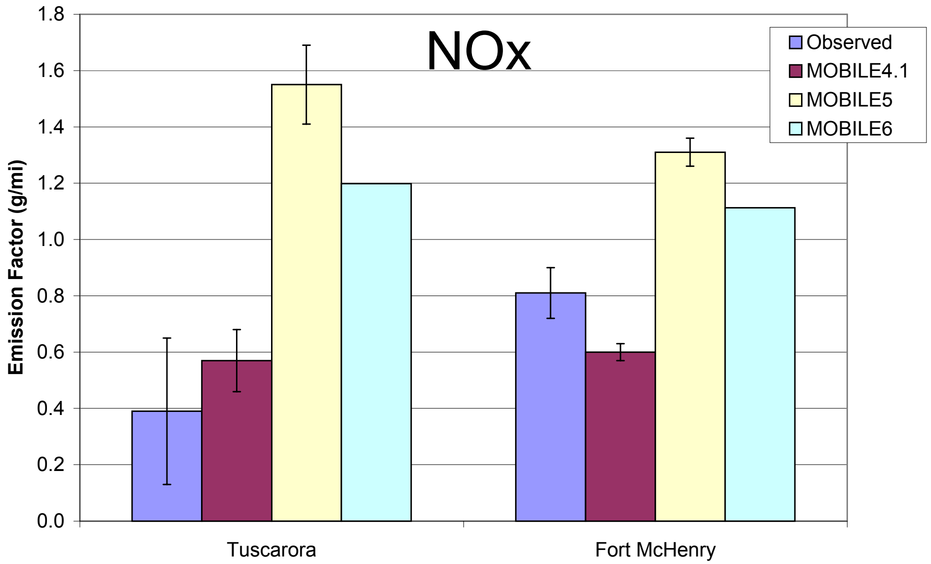
Tunnel Study Comparisons:
Light-Duty Vehicle Emission Factors







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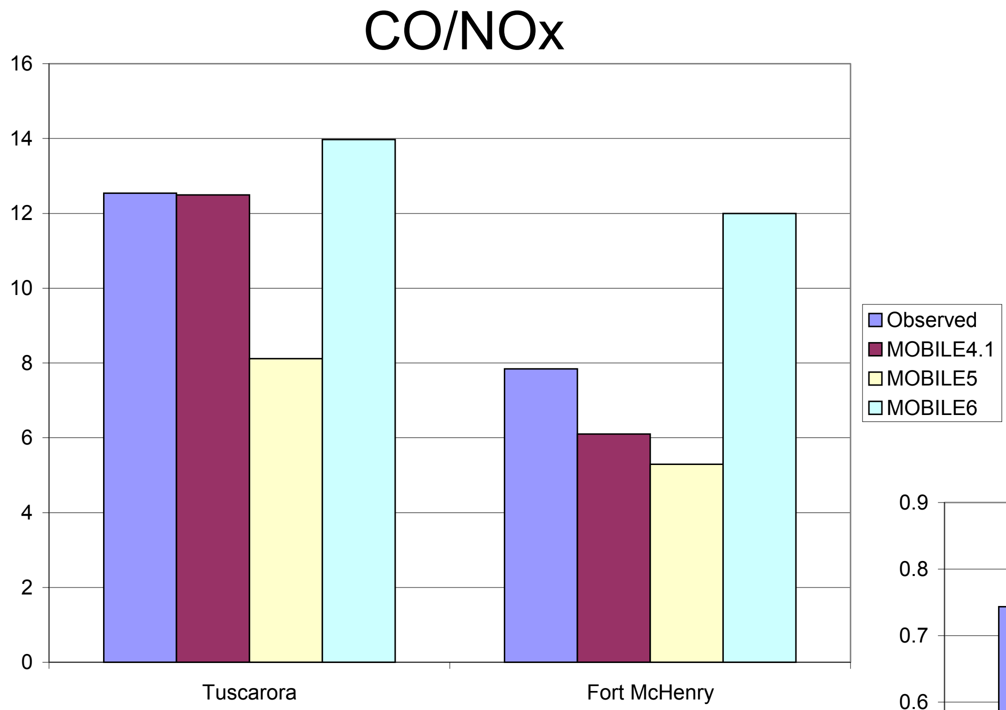
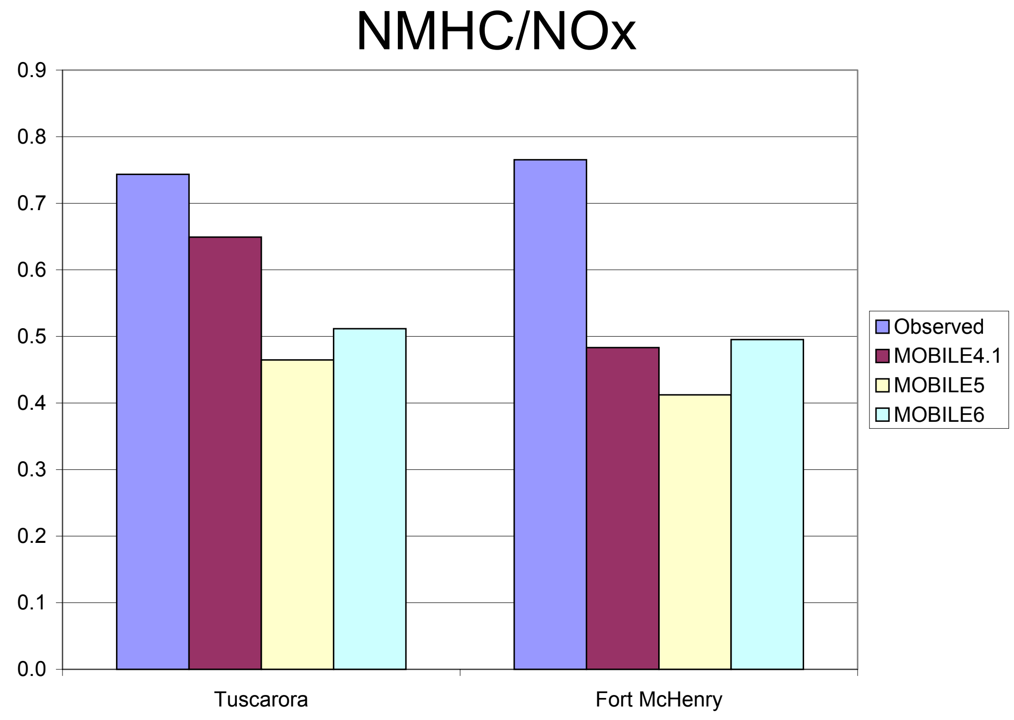
Tunnel Study Comparisons: Light-Duty Vehicle Emission Factor Ratios





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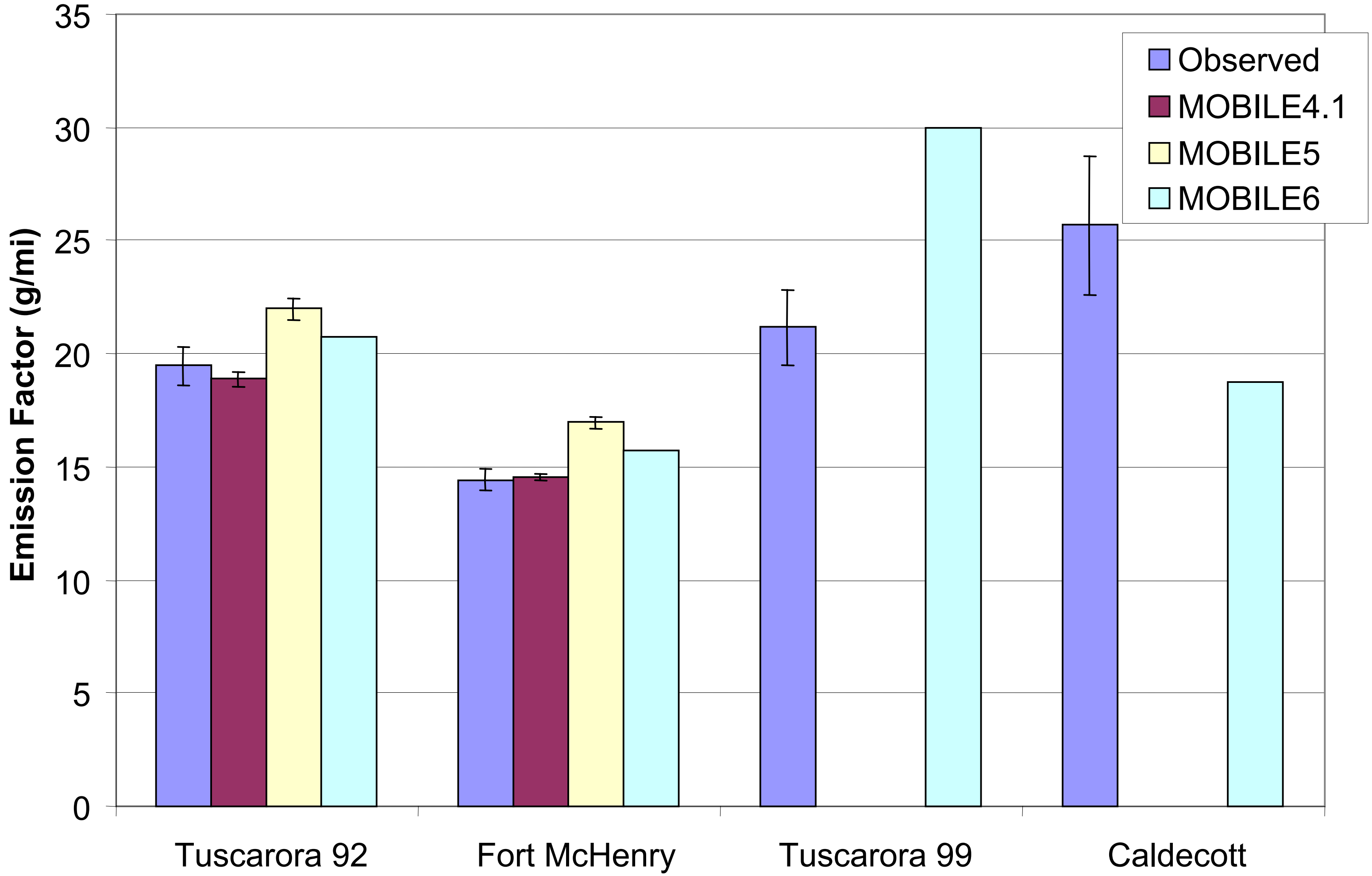
Tunnel Study Comparisons: Heavy-Duty Diesel Vehicle NOx Emission Factors



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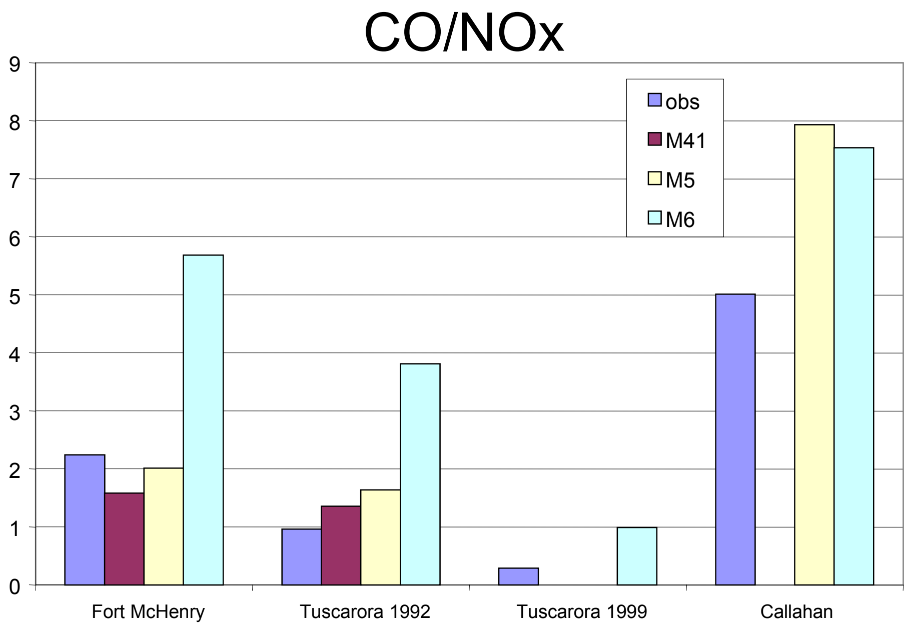
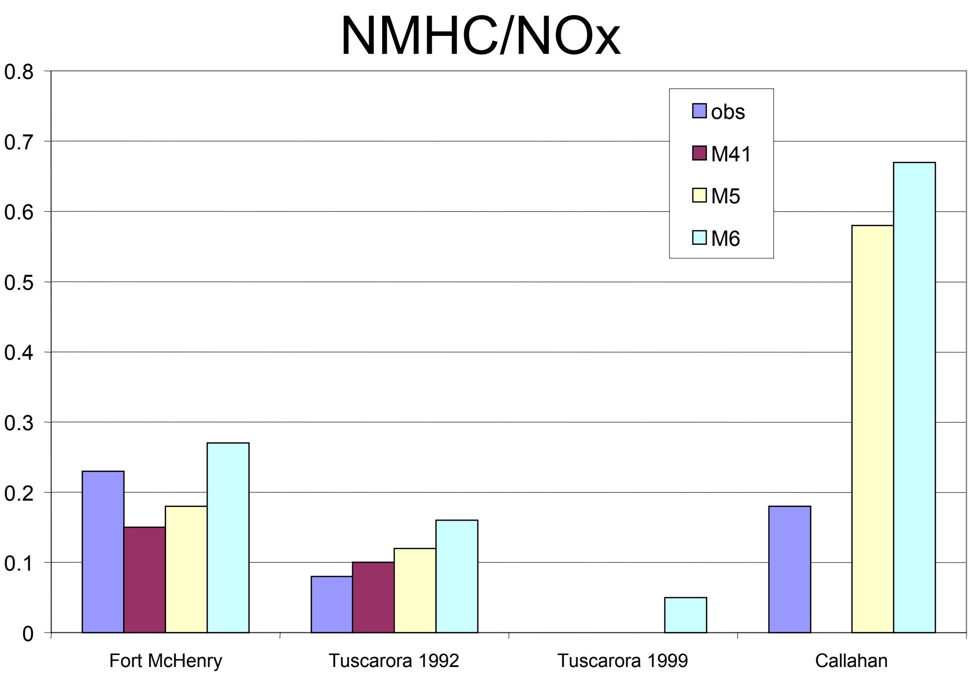
Tunnel Study Comparisons:
Fleet Average Emission Factor Ratios





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Tunnel Study Comparisons: Discussion

Factors updated in MOBILE6 include:

1. Off-cycle driving and air conditioning
2. Catalyst sulfur effects
3. HD excess NOx (only on MY 1988-2000)
4. Newer technology deterioration
5. Facility-specific speed correction factors

Nation-wide, all changes produce fleet-average increases (relative to MOBILE5) of approximately:

Year	CO	NO_X	VOC
1992	60%	25%	50%
1995	50%	25%	45%

Source: EPA presentation on MOBILE5/MOBILE6 at NAMVECC, 2001.

Tunnel Study Comparisons: Discussion (continued)

- Updated speed corrections can have significant impacts and the effects' directions depend upon the speed and pollutant.
- Approximate effects for the speeds observed in the tunnels (MOBILE6 relative to MOBILE5) for light-duty vehicles:

Tunnel	Avg. Spd.	CO	NO_X	VOC
Ft. McHenry	48 mph	+100%	-25%	+40%
Tusc. Mt.	58 mph	+100%	-40%	+15%
Callahan	26 mph	+20%	-15%	+15%

Tunnel Study Comparisons: Discussion (continued)

- MOBILE6 NOx fleet average predictions are somewhat lower than MOBILE5 results, and are relatively close to the observed data.
- Small differences between MOBILE6 and MOBILE5 NMHC. MOBILE6 tends to over-predict when the observed emission factors are small and under-predict when they are large. High emitters during one of the Tuscarora runs may influence the results.
- MOBILE6 CO results are much higher than both observed and MOBILE5 values for Ft. McHenry and Tuscarora Mt. However, they are slightly lower (than MOBILE5) for the Callahan Tunnel. This is partially due to the lower humidity at Ft. McHenry and Tuscarora which decreases A/C usage.

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Medium & Heavy Heavy-Duty Trucks

Class 8a
33,001 – 60,000 GVW

Class 8b
>60,000 GVW

Class 7
26,001 – 33,000 GVW

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Comparison of Heavy-Duty Diesel Vehicle (HDDV) Chassis Data with MOBILE6

- Chassis dynamometer data available for THC, CO, NOx, and PM emissions
- Match test cycle data with MOBILE6 estimate by appropriate facility type and average speed
- Account for differences in
  - Test Cycles
    - Heavy and Medium HD Trucks (UDDS, WVU, CSHVR-ARB cycles)
    - Transit Bus (CBD, others)
    - Garbage Truck (NY cycle)
    - Light HD Trucks (Light-duty FTP, US06 and other LD speed cycles)
  - Gross Vehicle Weight Rating (and curb weight)
  - Model year
  - Odometer

Heavy-Duty Diesel Vehicle (HDDV) Chassis Data

- Data sources:
  - WVU (DOE, ARB, NYDEC, CRC, etc.)
  - CE-CERT (primarily light HDDV)
  - CIFER (high altitude; NFRAQS and EPA)
  - SwRI (EPA studies)
  - Environment Canada
- Data taken on a number of test cycles ranging from 2 to 40 mph; ~20 mph most prevalent
- Class 8 trucks most heavily tested (limited data available for other truck classes and transit buses)

MOBILE6 HDDV Emission Rates

- MOBILE6 uses HDDV engine certification test data
- Converts engine work to g/mile emission rate:

$$MOBILE6\ EF\ (g/mile) = EF\ (g/hp\text{-}hr) * \rho / (FE * BSFC)$$

EF = emission factor from engine testing with adjustments

FE = fuel economy (miles/gallon)

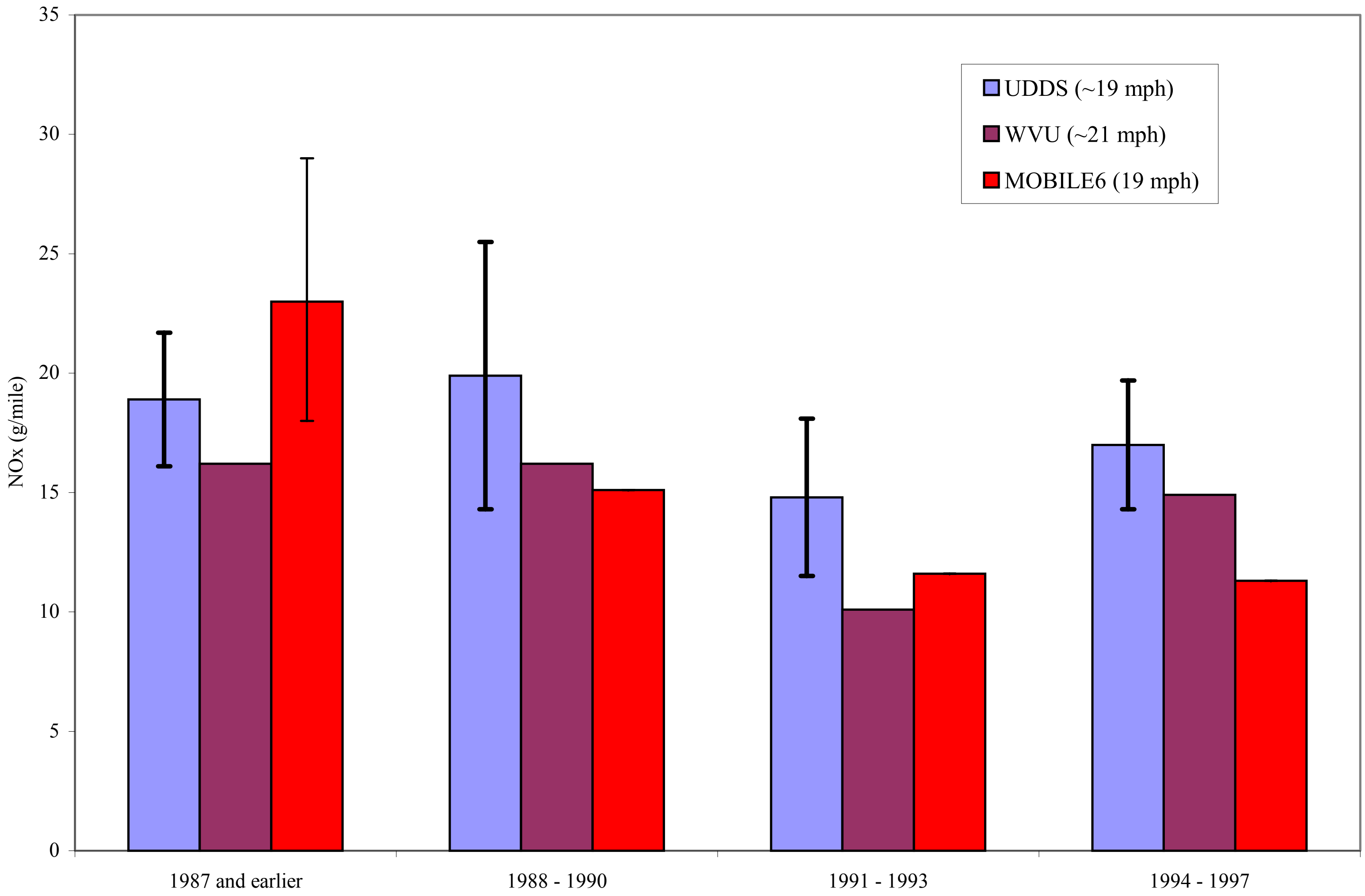
BSFC = brake specific fuel consumption (lb./hp-hr)

ρ = fuel density (lb./gal.)

Medium & Heavy Heavy-Duty Diesel Trucks (MHDDV & HHDDV) Data Issues

- The data did not indicate an emission difference between pre and post 1978 so pre-1988 vehicles were grouped in the graphs
- MOBILE6 predicts higher emission rates for 1978 and earlier than for 1979 – 1987 trucks and are represented in the following graphs as an range bar for older model years predictions for MOBILE6 estimates
- For chassis dynamometer test data, error bars (90% conf. level) are shown only for data averages with 3 or more data points by model year and test cycle disaggregation
- MOBILE6 does not provide error bars on model predictions

Comparison of MOBILE6 and Chassis Test Data: Class 7 Trucks (arterial)



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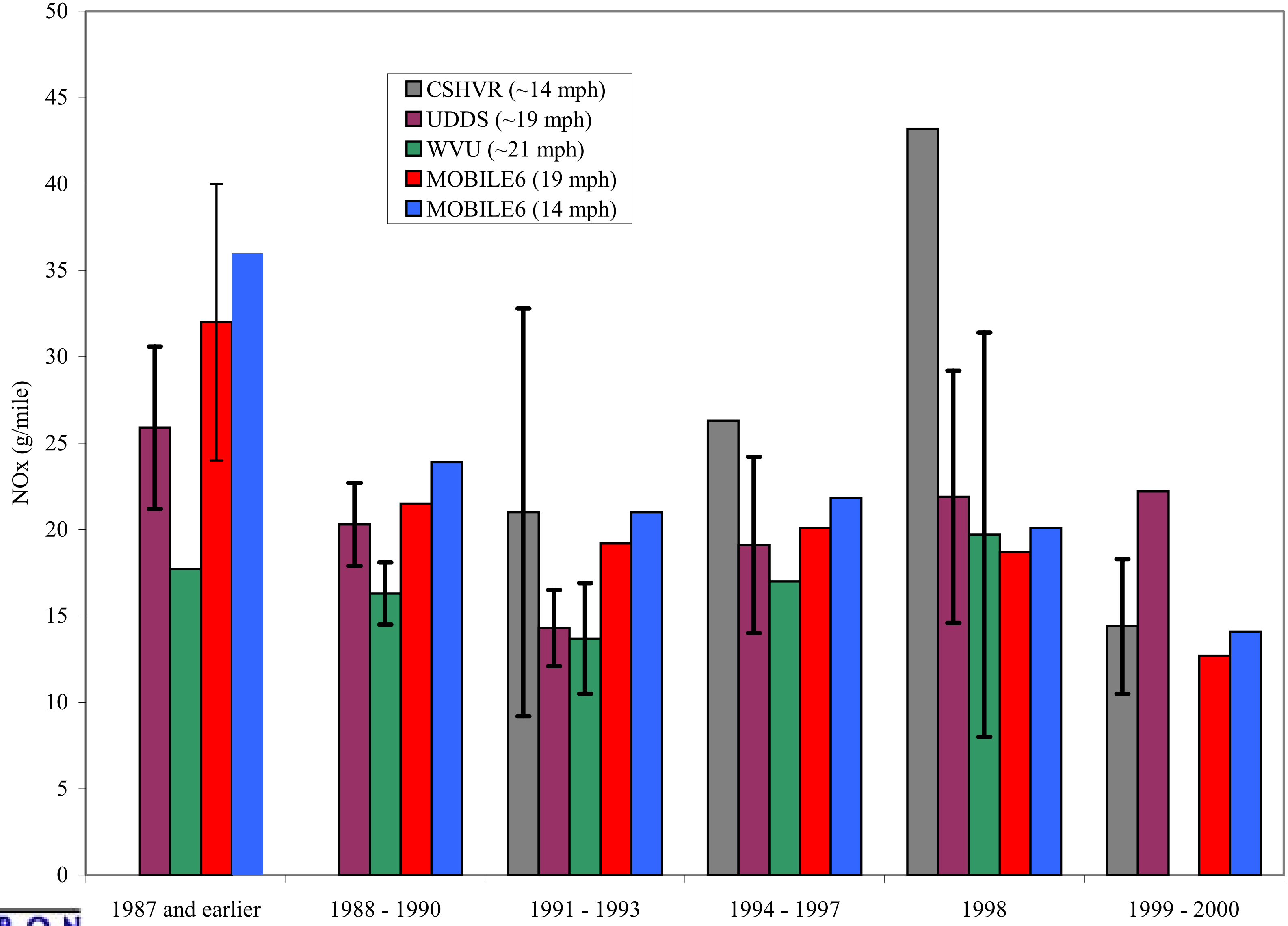
Comparison of MOBILE6 and HDDV Chassis Test Data: Class 8a NOx Emission Factors (arterial)



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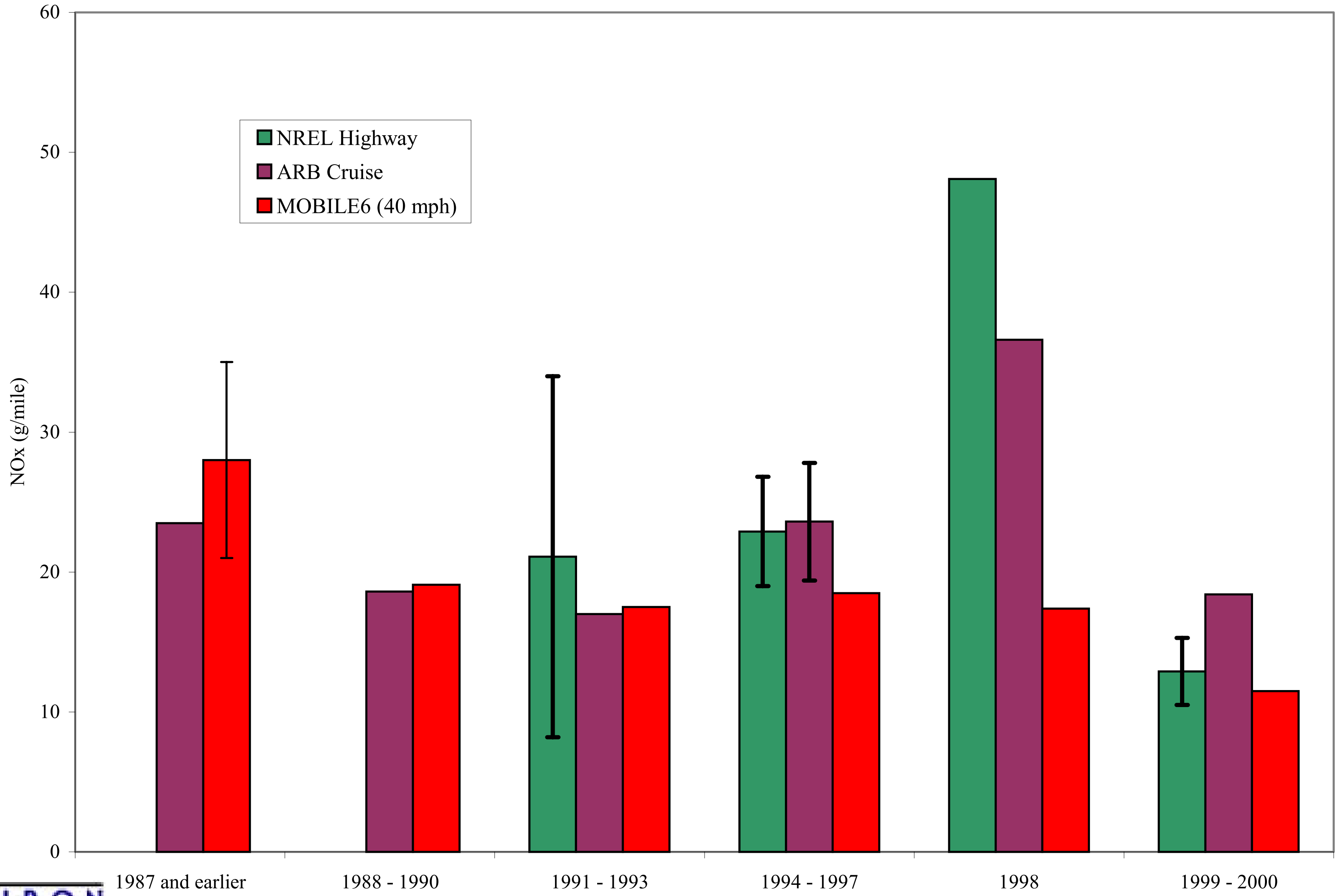
Comparison of MOBILE6 and HDDV Chassis Test Data: Class 8a NOx Emission Factors (40 mph highway)



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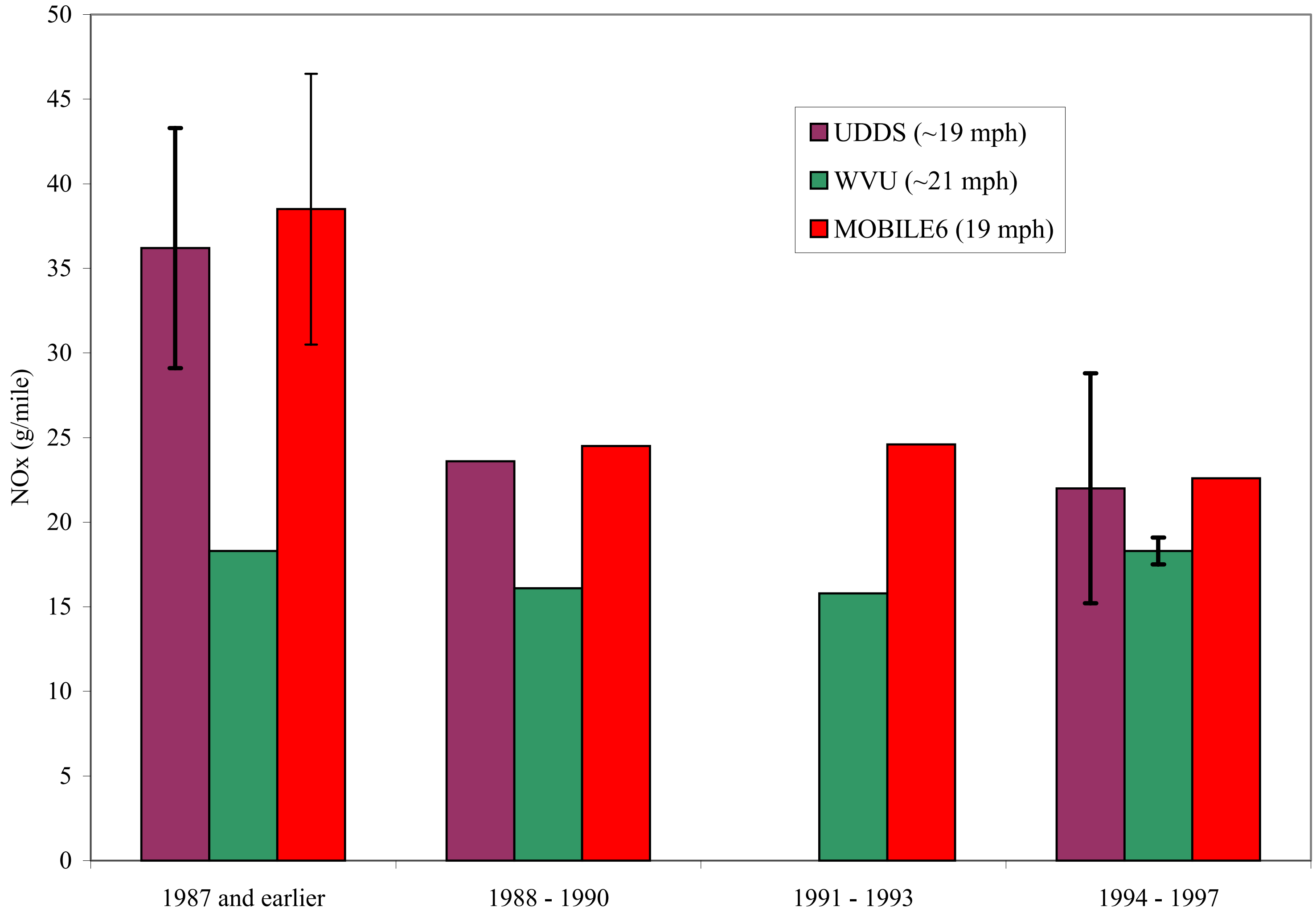
Comparison of MOBILE6 and HDDV Chassis Test Data: Class 8b NOx Emission Factors (20 mph arterial)



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Comparison of MOBILE6 and HDDV Chassis Test Data: Discussion

- MOBILE6 predictions for HC and CO emissions were similar to average emissions for most model years in the data analyzed.
- MOBILE6 generally predicted higher NOx emissions for older vehicles (1978 MY and earlier) and lower NOx emissions for late model vehicles (1994 and later) than the average measurements in the limited data set.
- High emitters could be important for THC, CO, and PM emissions based on limited chassis dynamometer test data.
- Cold start emissions were found for late model and older diesel engines regardless of aftertreatment devices; a start methodology for modeling HDV emissions is recommended.

MOBILE6 Model Evaluation Project: Work in Progress

- Reconciliation of MOBILE6-based emission inventories with ambient data
- Comparisons with remote sensing data

Reports will be posted on CRC web site

http://www.crcao.com/

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