

Emissions of Radical Precursors and Related Species from Traffic in Houston, Texas – Implications for Air Quality Modeling

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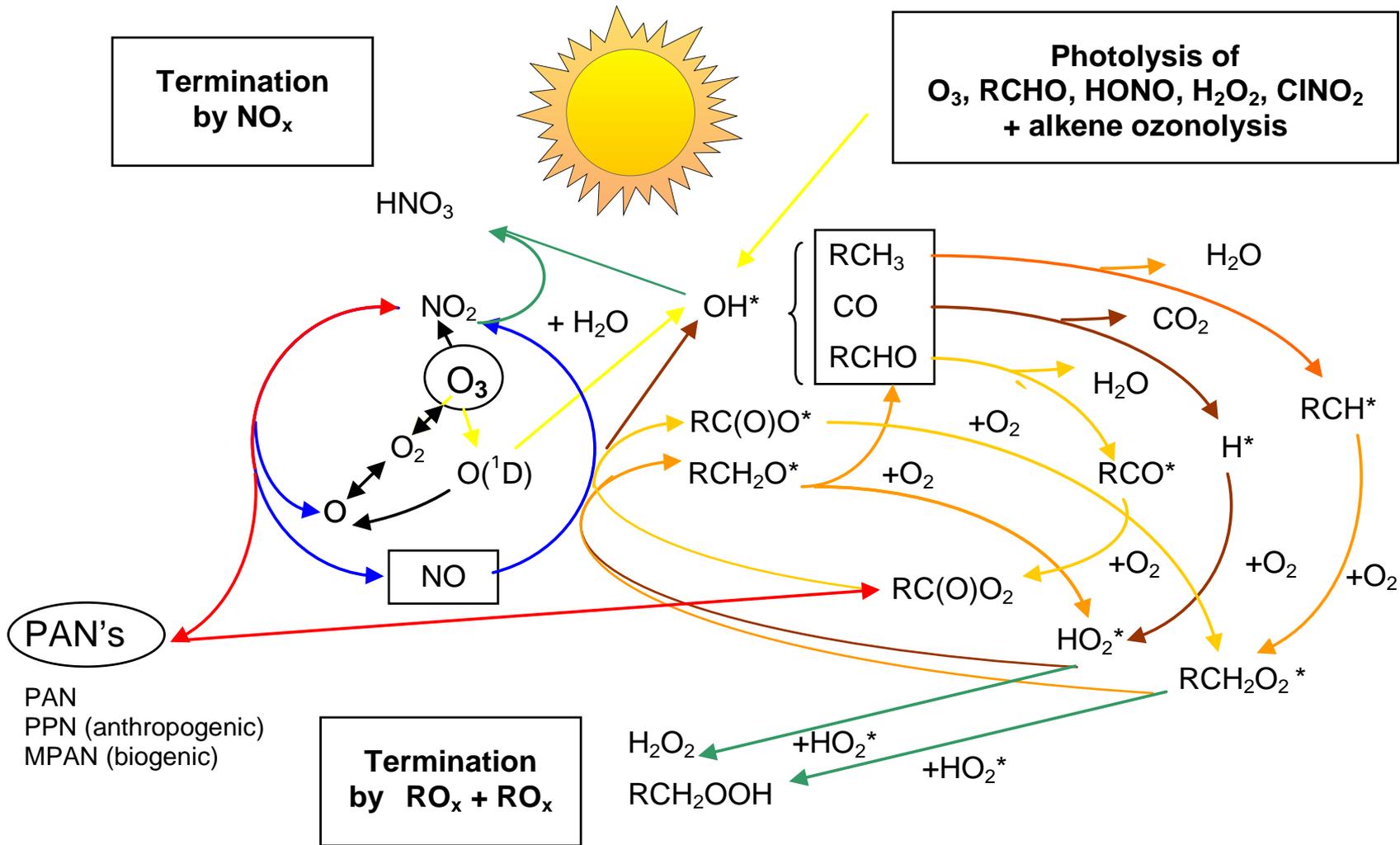
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Czader and Luis Ackermann – University of Houston



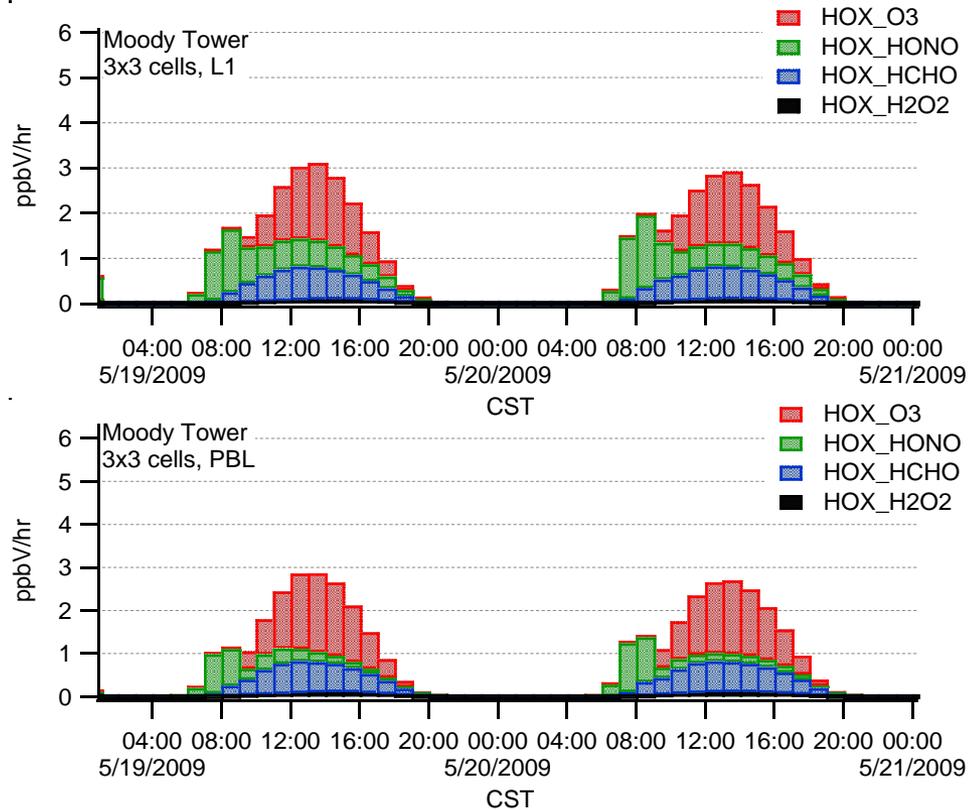
Background

- The Houston region is in non-attainment for the 1-hr, 1997 and 2008 8-hr ozone standard
- This study focus on ozone precursors: HONO, HCHO, CO, NO/NO₂/NO_x
- Observational data is compared to modeling data (MOBILE6 and MOVES) on an urban highway junction in Houston

Daytime Photochemical Process



CMAQ modeling of contributions of O₃, HONO, HCHO and H₂O₂ to hourly OH formation in Houston TX



- HCHO contributes to OH formation on late morning hours
- HONO contributes to OH formation on early morning hours

Experimental Data

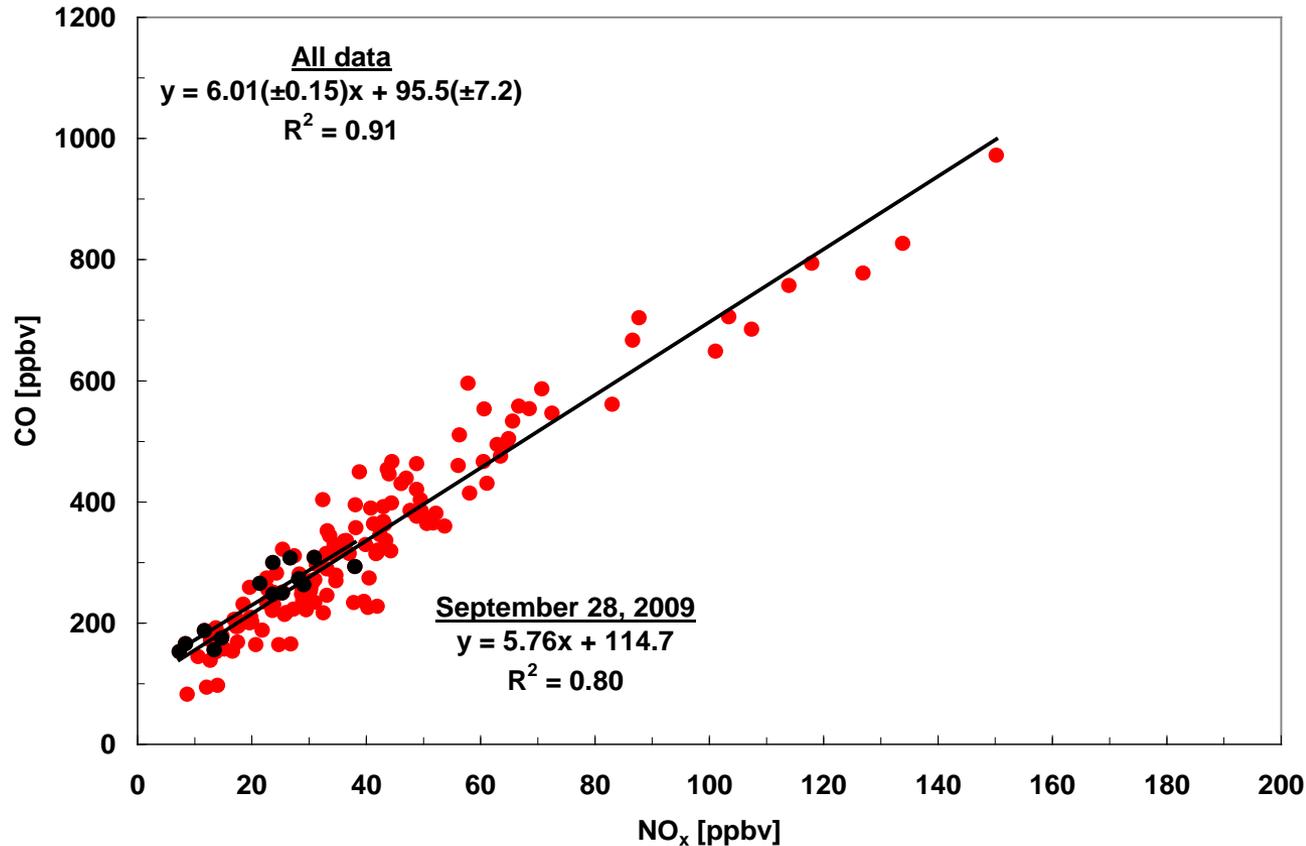


- Continuous ambient air measurements averaged to 10 min interval

Experimental Data

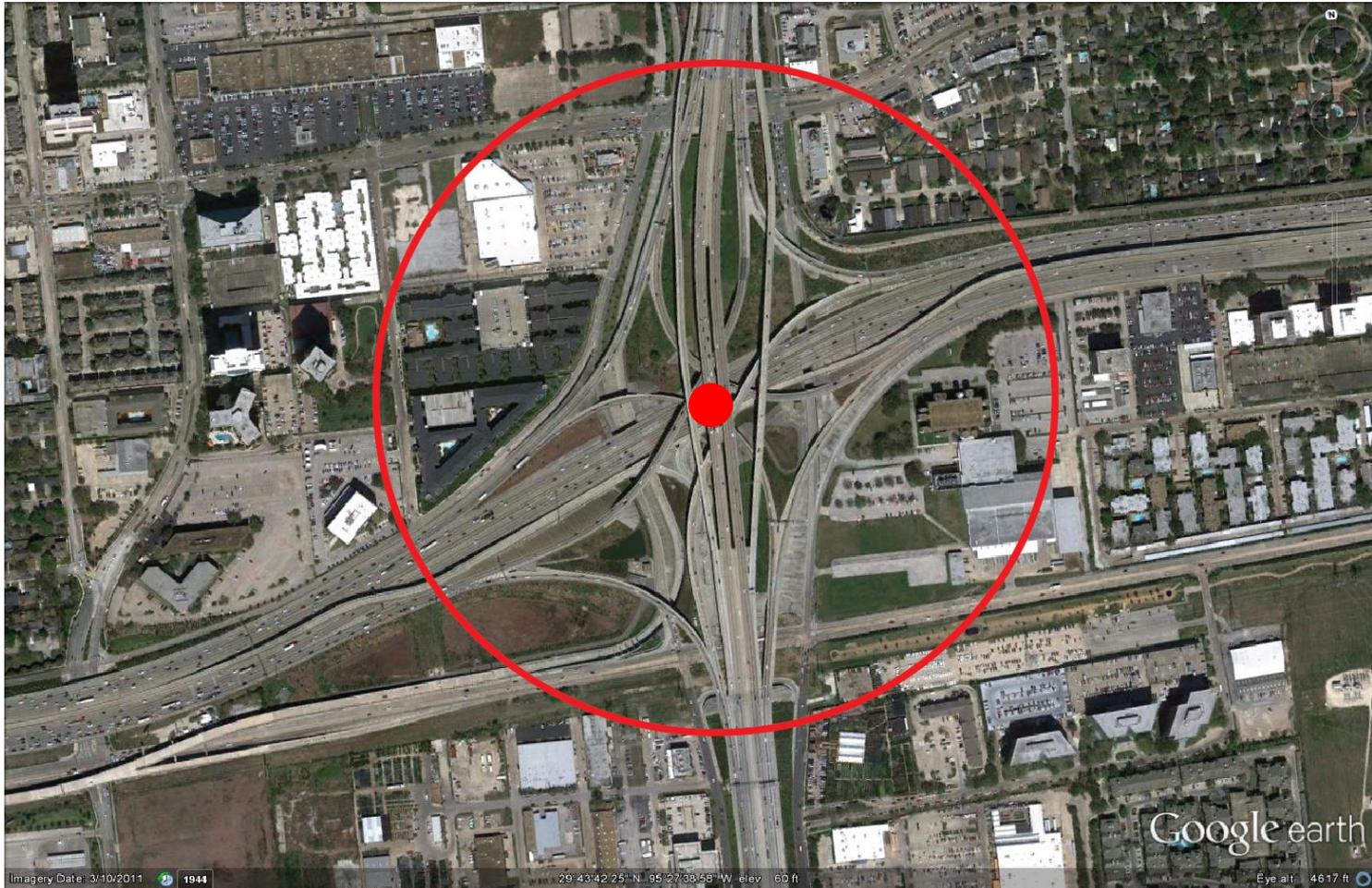
- The data was screened for:
 - weekdays
 - Rush hour time 4-8 am CST
 - Global radiation $< 10 \text{ W/m}^2$
 - PAN $< 50 \text{ pptv}$
 - No precipitation
 - RH $> 80\%$

Experimental Data



- Very good agreement with Parrish study for rush hour times in selected cities.

Emission Modeling



Emission Modeling

- **MOBILE6:** hourly Harris county emission factors for on-road for NO_x, CO, VOC, HCHO
 - Observed meteorology at the Galleria site for the model day: September 28, 2009
 - 2009 local registration distribution
 - 2009 local diesel fractions
 - 2009 local VMT per hour
 - Local inspection and maintenance program
 - Anti-tampering program
 - Reformulated gasoline

Emission Modeling

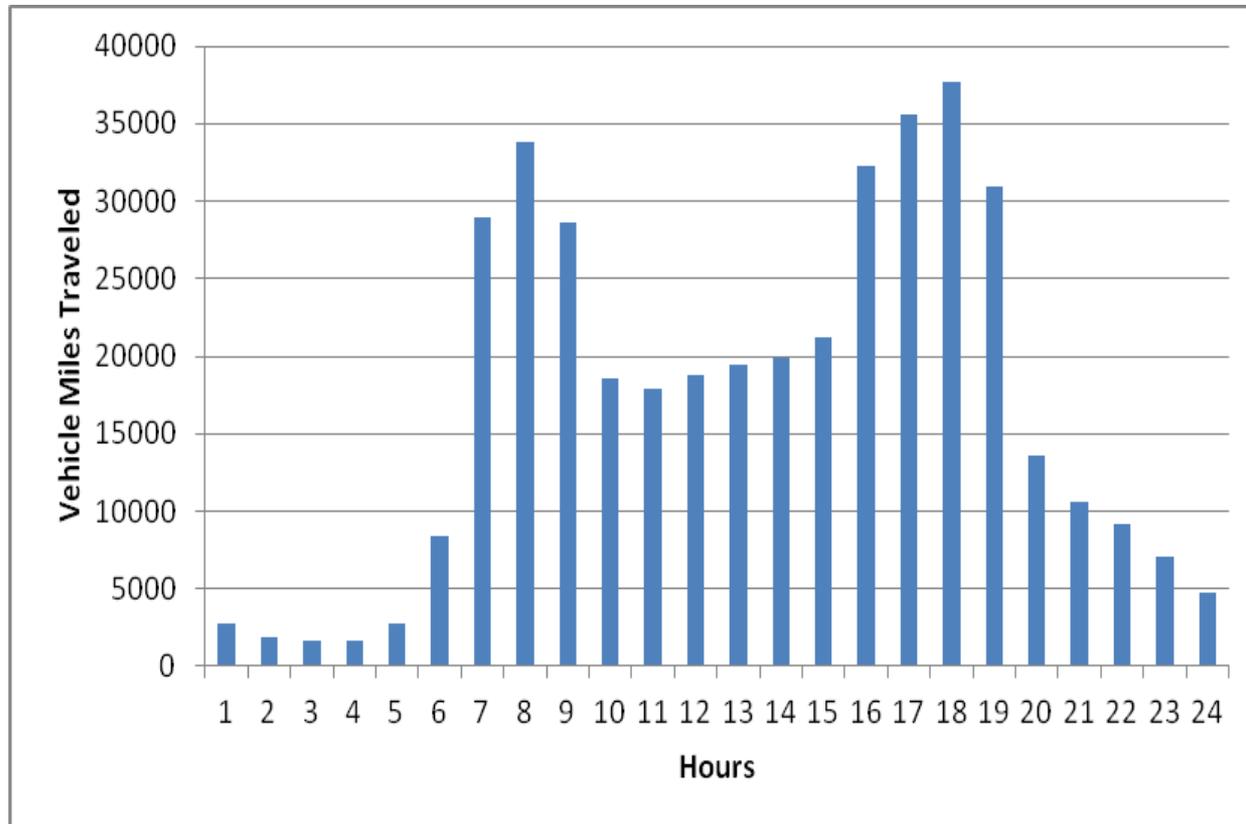
- **MOVES:** MOVES2010a was used to calculate EF for on-road and off-network for NO_x, CO, VOC, HCHO, CO₂ (atm), NO, NO₂. MOVES2010b was used to calculate HONO.
 - The county data manager was used to enter the local data:
 - Avgspeeddistribution
 - Dayvmtfraction
 - Fuelformulation
 - Fuelengfraction
 - Fuelsupply
 - Hourvmtfraction
 - Hpmsvtypeyear
 - Imcoverage
 - Monthvmtfraction
 - Roadtypedistribution
 - Sourcetypeagedistribution
 - Sourcetypeyear
 - Zonemonthhour

Emission Modeling

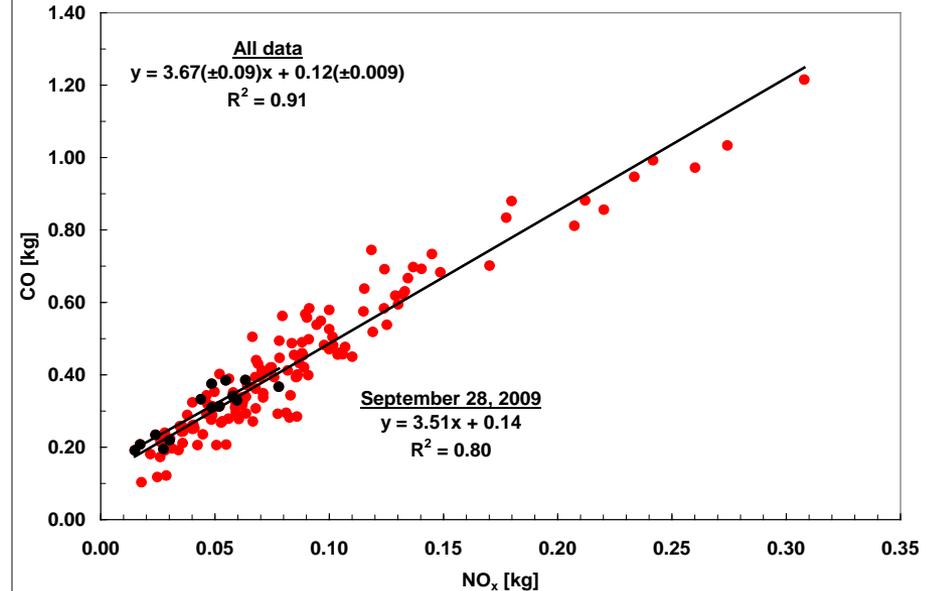
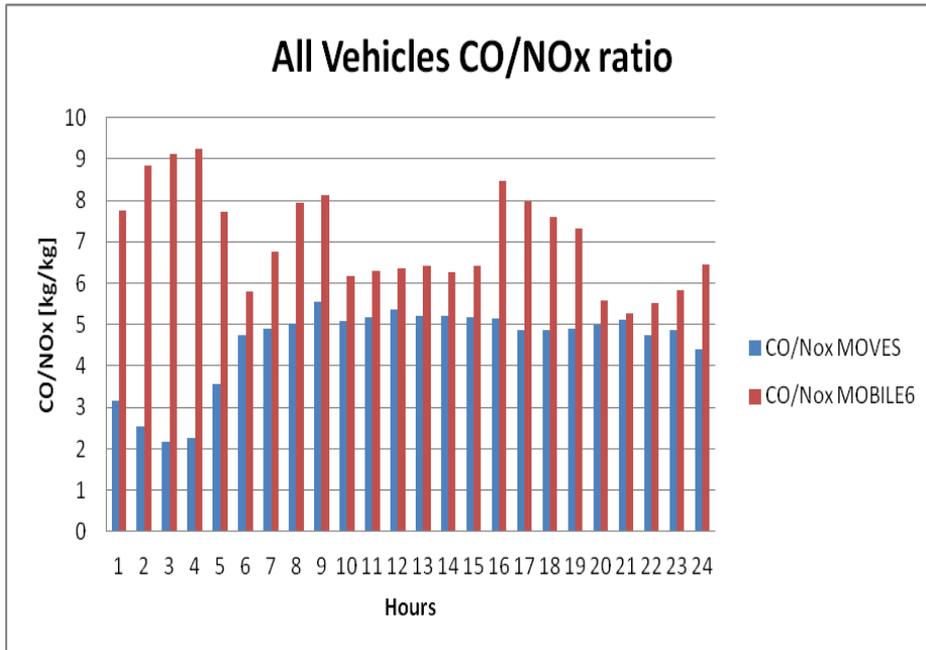
Using the Texas Transportation Institute suite of programs:

- The EFs were adjusted for TxLED and the motorcycle rule
- The emissions were calculated multiplying the hourly adjusted emission factors (according to speed) by the hourly VMT per link, using the 2009 hourly VMT mix.
- The output is link-level emissions by vehicle type

Diurnal variation of VMT for the Galleria site study area September 28, 2009



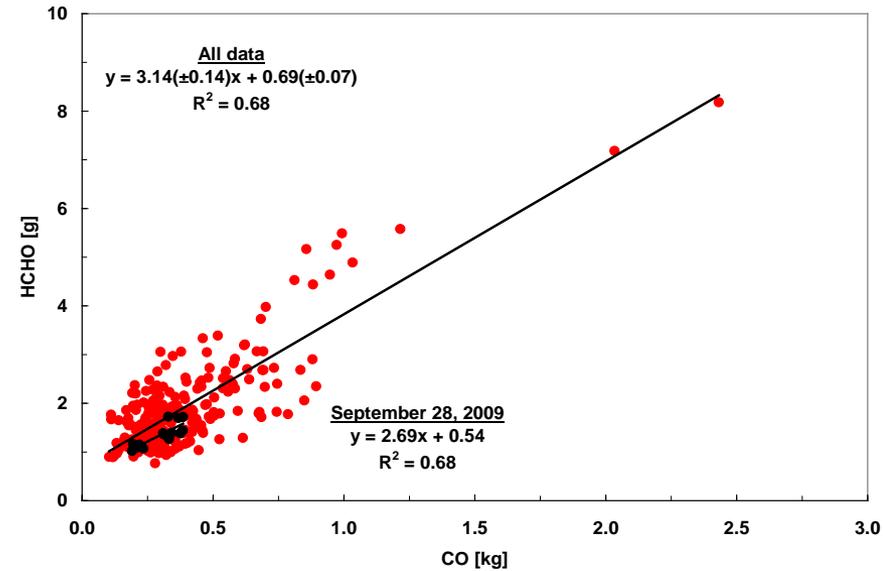
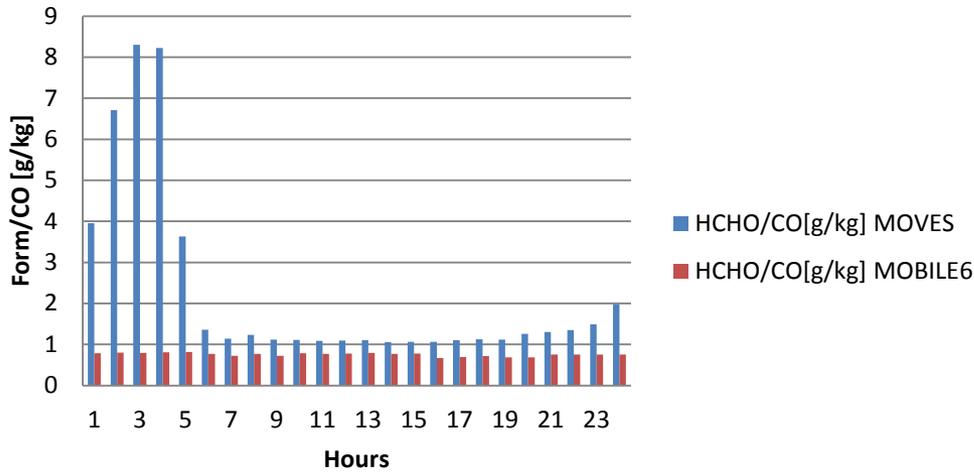
Results



- For the morning rush hour, MOBILE6 overestimates the CO/NO_x ratio by almost a factor of 2, while MOVES is 30% higher

Results

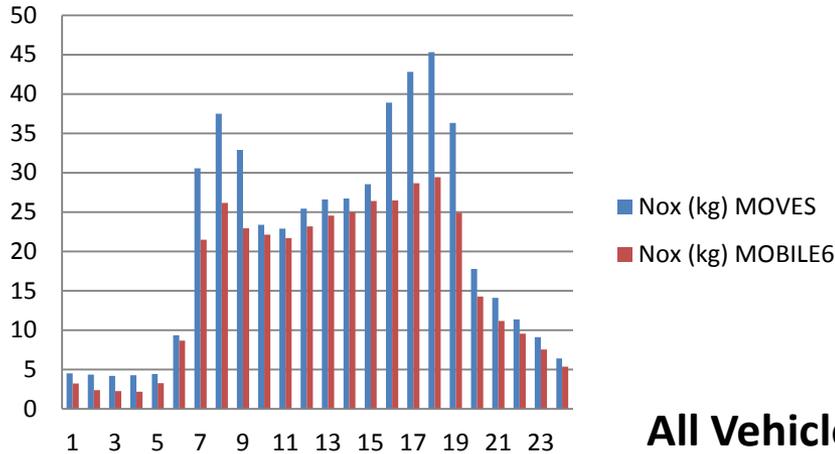
All Vehicles HCHO/CO ratio



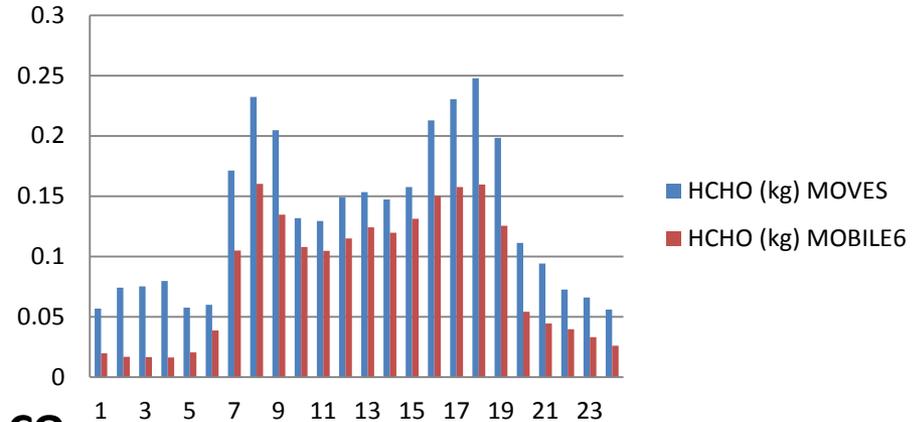
- MOBILE6 largely underestimates HCHO/CO ratio
- MOVES calculates a very high ratio for very early morning due to heavy duty diesel off-road emissions (idling and starting trucks)

Results

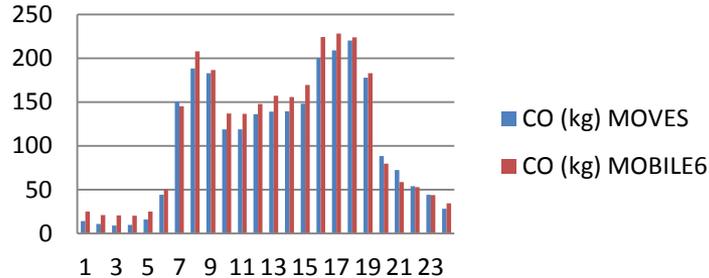
All vehicles NOx



All Vehicles HCHO



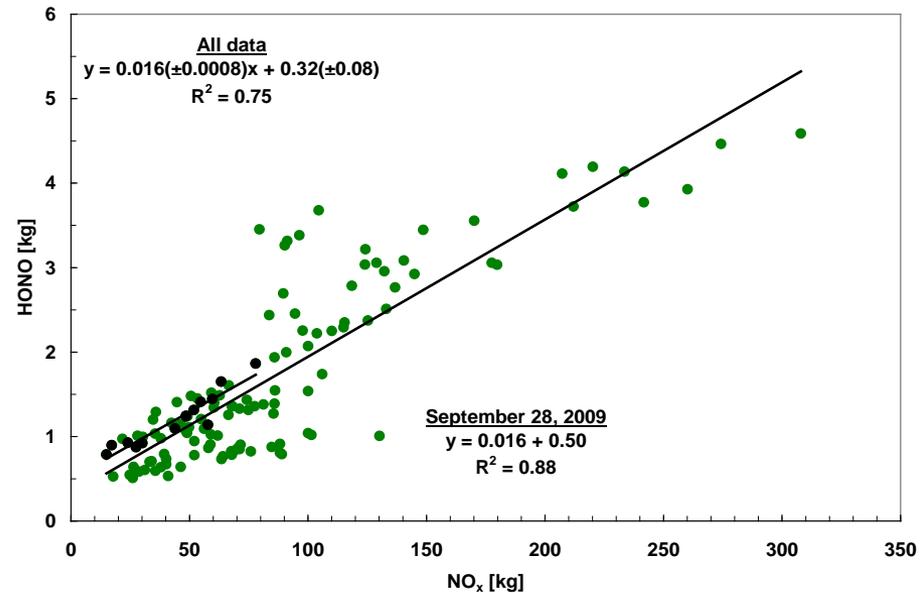
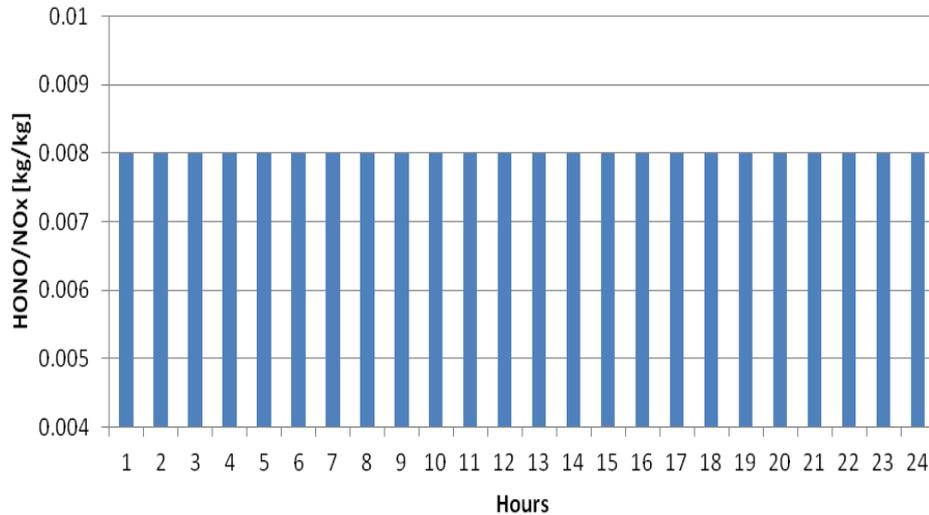
All Vehicles CO



- The differences in CO/NOx and HCHO/CO ratios are largely due to higher NOx and HCHO in MOVES (30% and 57% more than in MOBILE6) while CO emissions are about the same for both models.

Results

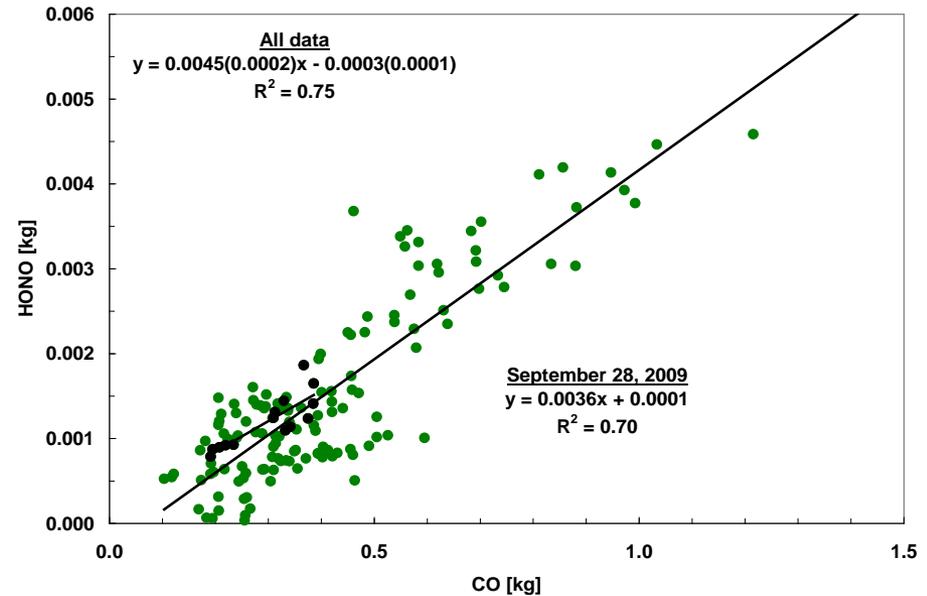
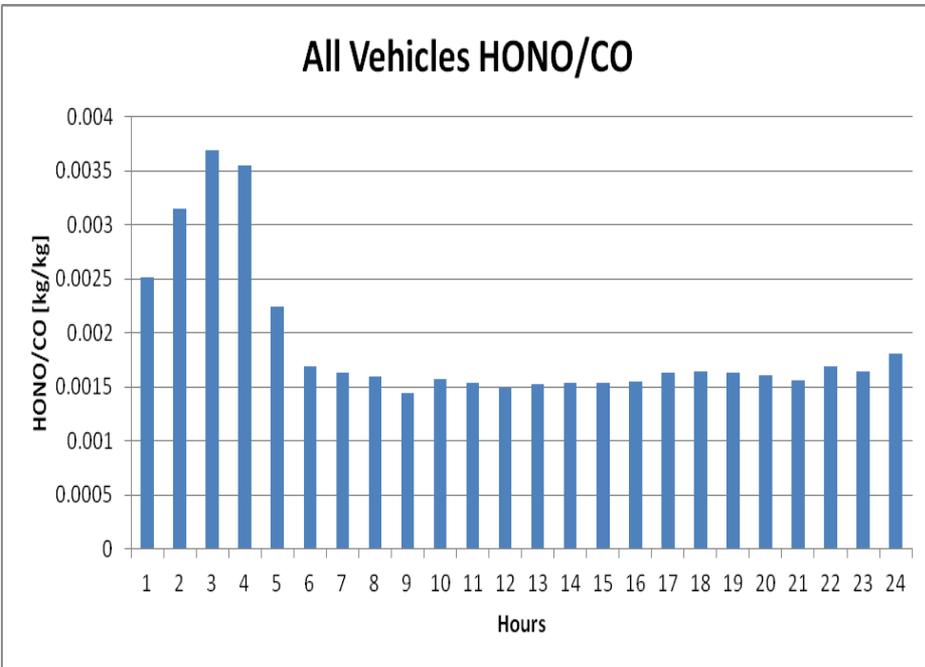
All Vehicles HONO/NOx ratio



MOVES shows a constant HONO/NOx ratio from a tunnel study done more than 15 years ago.

The observed HONO/NOx ratio is twice the modeled.

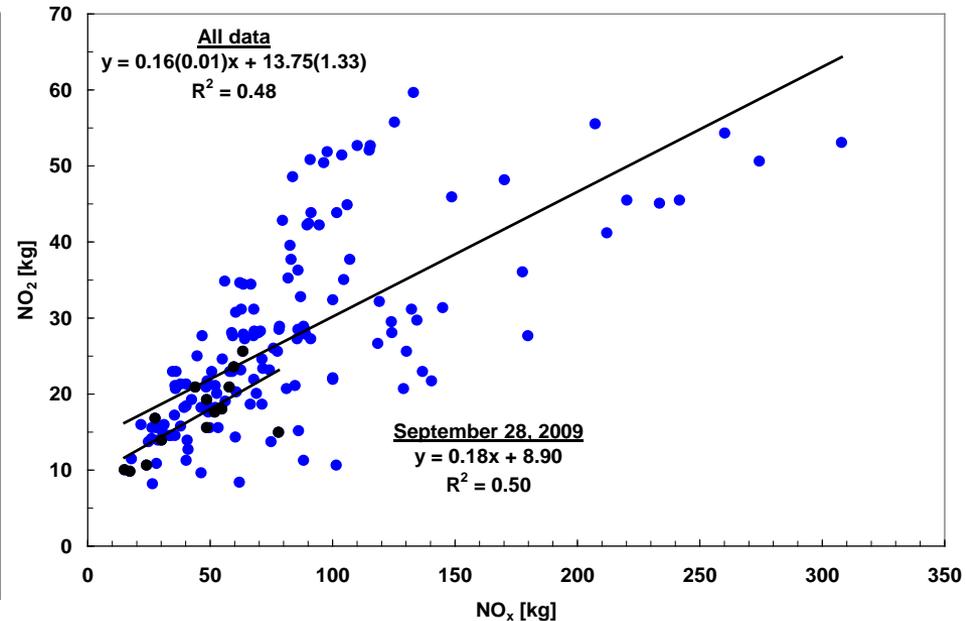
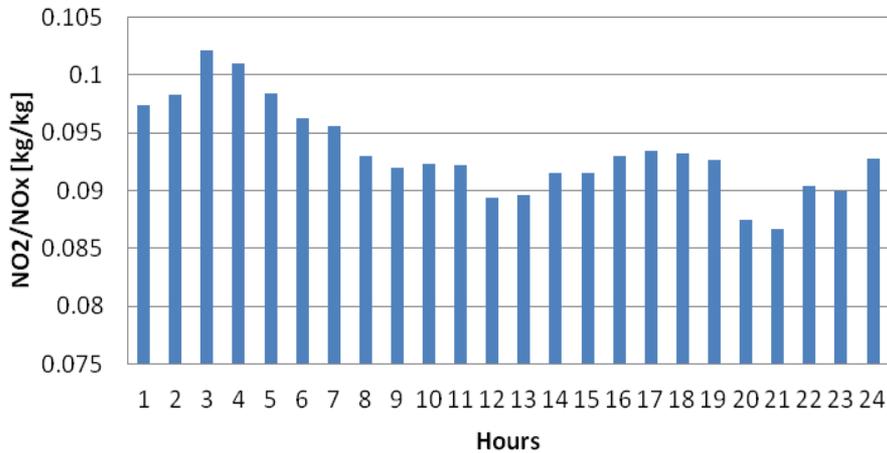
Results



- As expected due to the underestimation of HONO/NO_x, the MOVES also underestimates the HONO/CO ratio, except at very early morning hours.

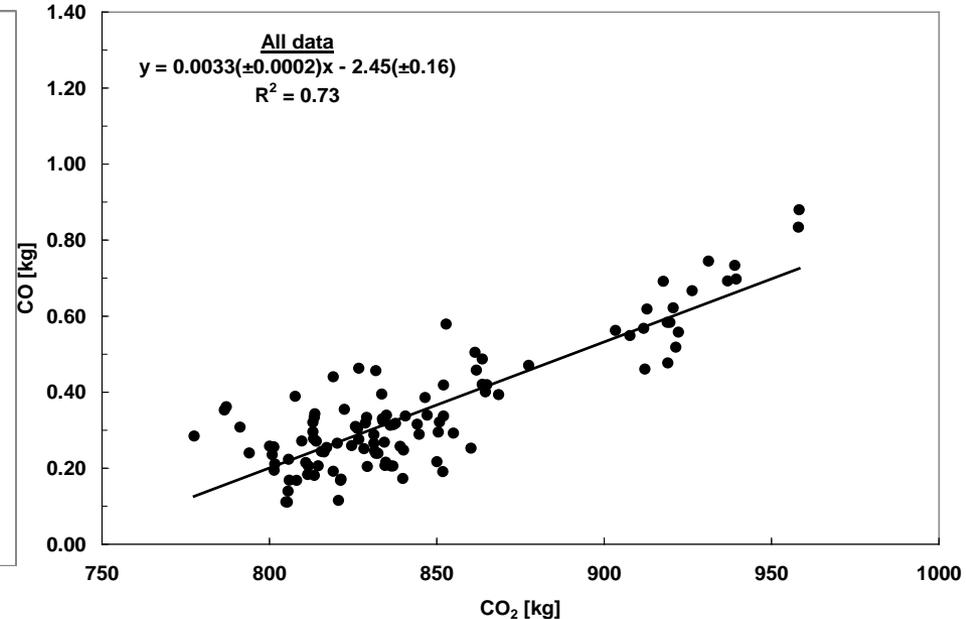
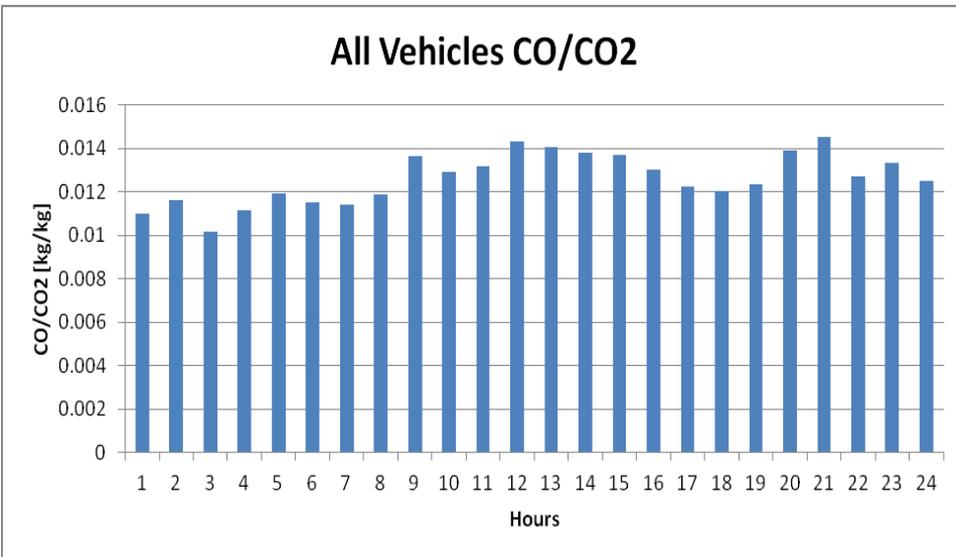
Results

All Vehicles NO₂/NO_x ratio



- Earlier studies showed a NO₂/NO_x ratio of 5%
- MOVES shows a ratio 9.3% for rush hour time
- The observation ratio is about twice

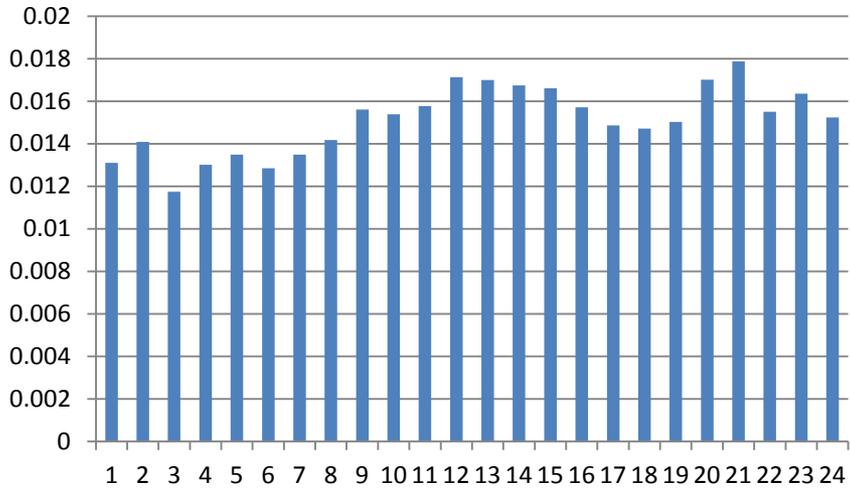
Results



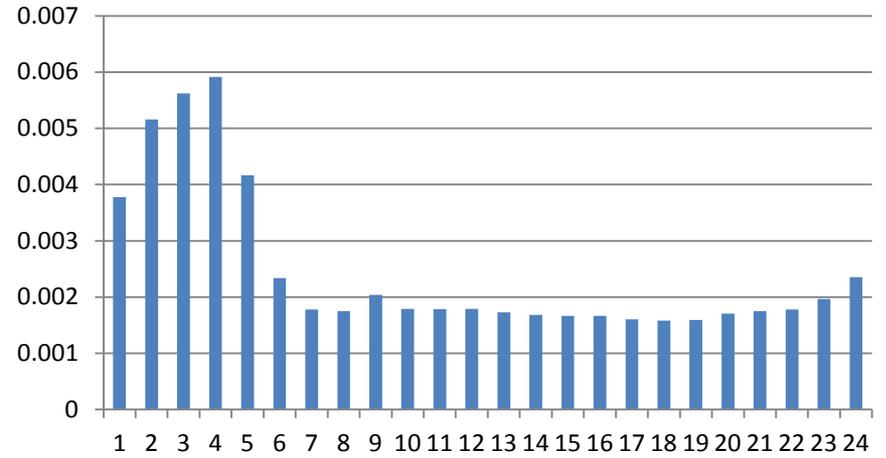
- MOVES calculates 3 times higher CO/CO2 than observed.
- It seems that MOVES overestimates the CO/CO2 ratio from light duty gasoline vehicles

Results

Light Duty Gasoline CO/CO2



Heavy Duty Diesel CO/CO2



Conclusions

- For CO/ NO_x ratio of around 6.01 ppbv CO / 1 ppbv NO_x ($r^2 = 0.91$) in agreement with other studies. MOBILE6 and MOVES, overestimate the corresponding observed emission ratio. MOVES gets closer, but is 30% above the observed value.
- For HCHO/CO ratio of around 3.14 ± 0.14 g HCHO / kg CO. While MOBILE6 largely underestimates this ratio, MOVES calculates higher ratios, but is lower than the observed ratio. MOVES shows high HCHO/CO ratios during the early morning hours due to heavy duty diesel off-road emissions (Potential reasons are idling and starting trucks).

Conclusions

- The differences of the modeled CO/NO_x and HCHO/CO ratios are largely due to higher NO_x emissions in MOVES (30% increased from MOBILE6) and higher HCHO emissions in MOVES (57% increased from MOBILE6); CO emissions were about the same in both models.
- The observed HONO/NO_x emission ratio is around 0.016 kg HONO / kg NO_x which is twice as high as in MOVES.
- The observed NO₂/NO_x emission ratio is around 0.18, which is twice than in MOVES.
- MOVES overestimates the CO/CO₂ emission ratio by a factor of 3 compared with the observations.
- The above findings indicate an overestimation of CO for light duty gasoline vehicles and an underestimation of HONO, HCHO, NO₂ for heavy duty diesel vehicles in MOVES.