Near-Road Monitoring of Ultrafine Particle Number from Heavy Duty Diesel Truck Traffic

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19th ETH-Conference on Combustion Generated Nanoparticles
June 28th - July 1st, 2015
at ETH Zentrum, Zürich, Switzerland

Background

- Exposure to ultrafine particles (UFP) may contribute to heart and lung diseases leading to hospitalization and premature death
- UFP are/will be measured near California roadways by local air districts (USEPA Near-Road Monitoring Rule)
- Condensation Particle Counters (CPC) characterize UFP by measuring particle number (PN) concentrations
- 2011: TSI released a water-based CPC (model 3783) intended for long-term, 24/7 operation (network use) in background and near-source (e.g. near-road) environments
- 2013: TSI released updated version of model 3783

Study Outline

- Collaboration between SCAQMD, ARB, UCLA, TSI and TAPI to study the performance reliability of the 3783 TSI model:
  - 2011 Study (Phase I): SCAQMD, UCLA, and ARB
    - May 16 to June 14
    - Three CPC models: 3781 (x3), 3783 (x3), and 3785 (x3)
    - Inter- and Intra-model variability
    - Pre-MATES IV evaluation

  - 2011 Study (Phase II): ARB, SCAQMD, TSI, and TAPI
    - June 2011 to April 2012
    - 3783 model (x3)
    - Continued testing of durability
    - Stopped due to continual instrument breakdown

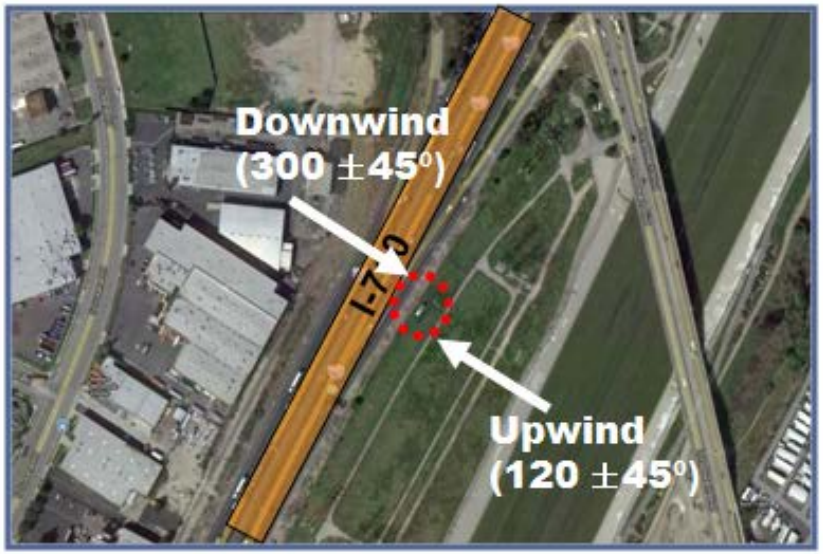
  - 2013 Study: ARB, SCAQMD, TSI, and TAPI
    - August 21, 2013 to April 17, 2014
    - Upgraded 3783 model (x3)
    - Testing of durability and precision

Site Location and Instrument Set-up

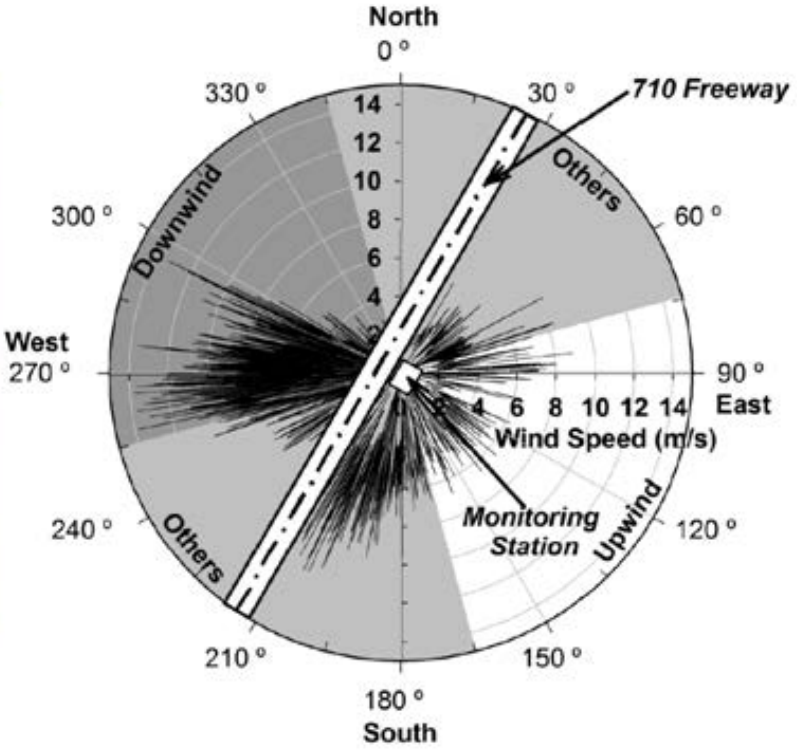
Site Location and Instrument Set-up

Sampling Period: 5/16/2011 – 6/15/2011

Surrounding Environment

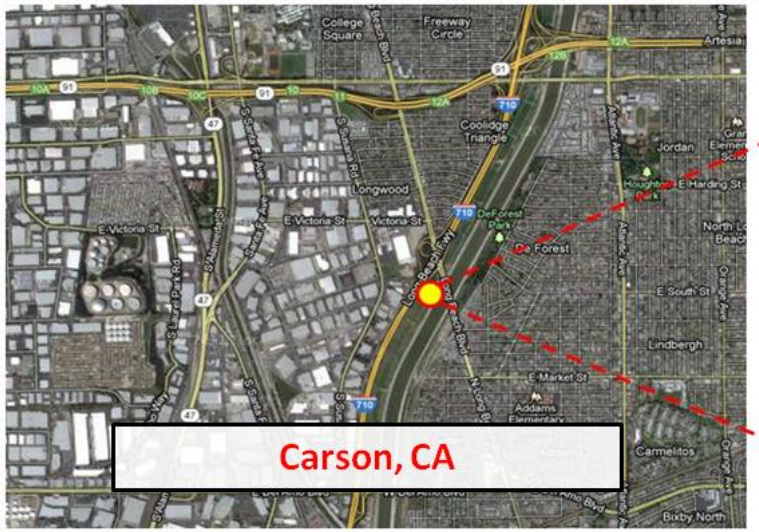


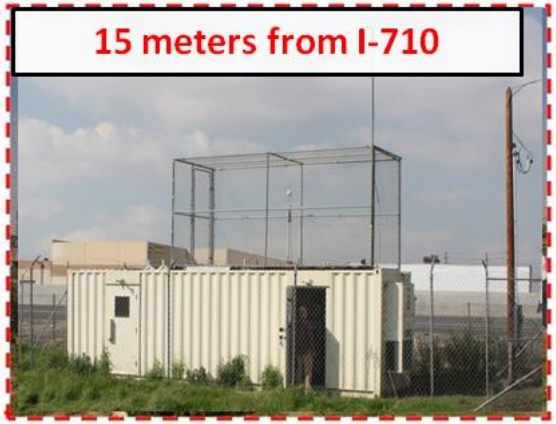
Wind Condition

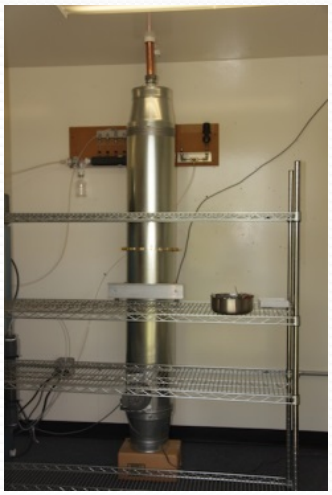


- Site is downwind of the I-710 freeway ~50% of the time

Site Location and Instrument Set-up



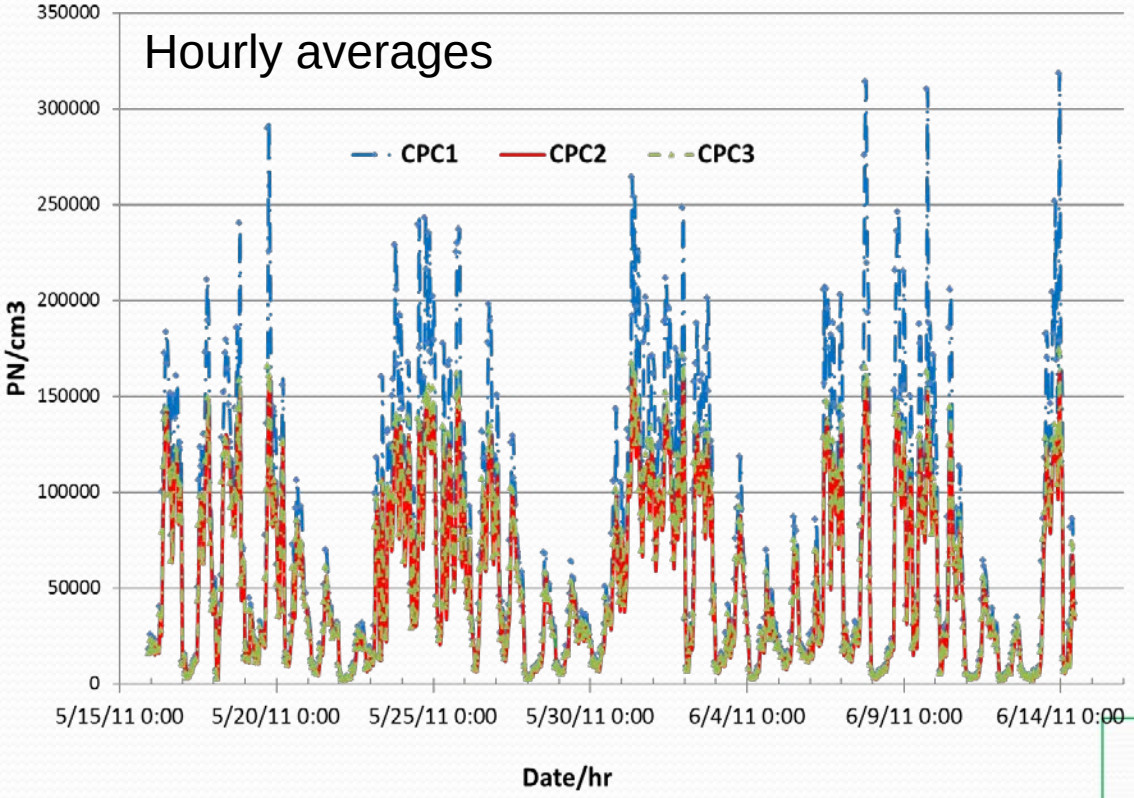


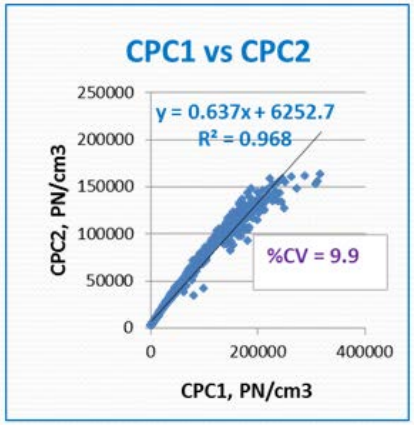


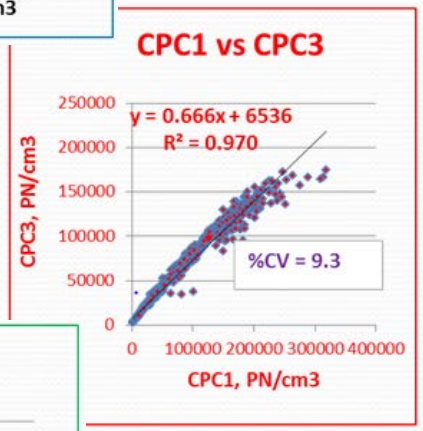
TSI Water CPC 3783

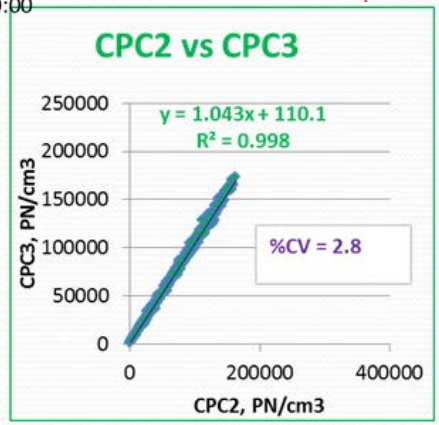
Min Detectable Diameter (D50)	**7 nm**
Maximum Detectable PN (#/cm^3)	**1 x 10^6**
Particle Counting Errors	**± 10%** *at 1x10^6 /cm^3*
Aerosol Flow Rates (L/min) optics / sample fow	**0.12 / 3.0**

2011 Study (Phase I; May 16 - June 14)
TSI 3783 Variability





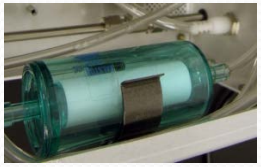




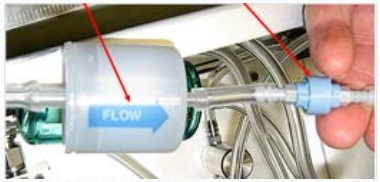
- 3783 exhibited some intra-model bias
  - Two CPCs within 5%
  - Third CPC differed by ~30%

3783 WCPC Design Modifications

- Longer growth tube & longer wick cartridge
- Vent Assist
- New protection filters for flow orifices
- New ejector pump for better reliability combined with lower water separator temp (7ºC vs. 20ºC)



Old (paper)

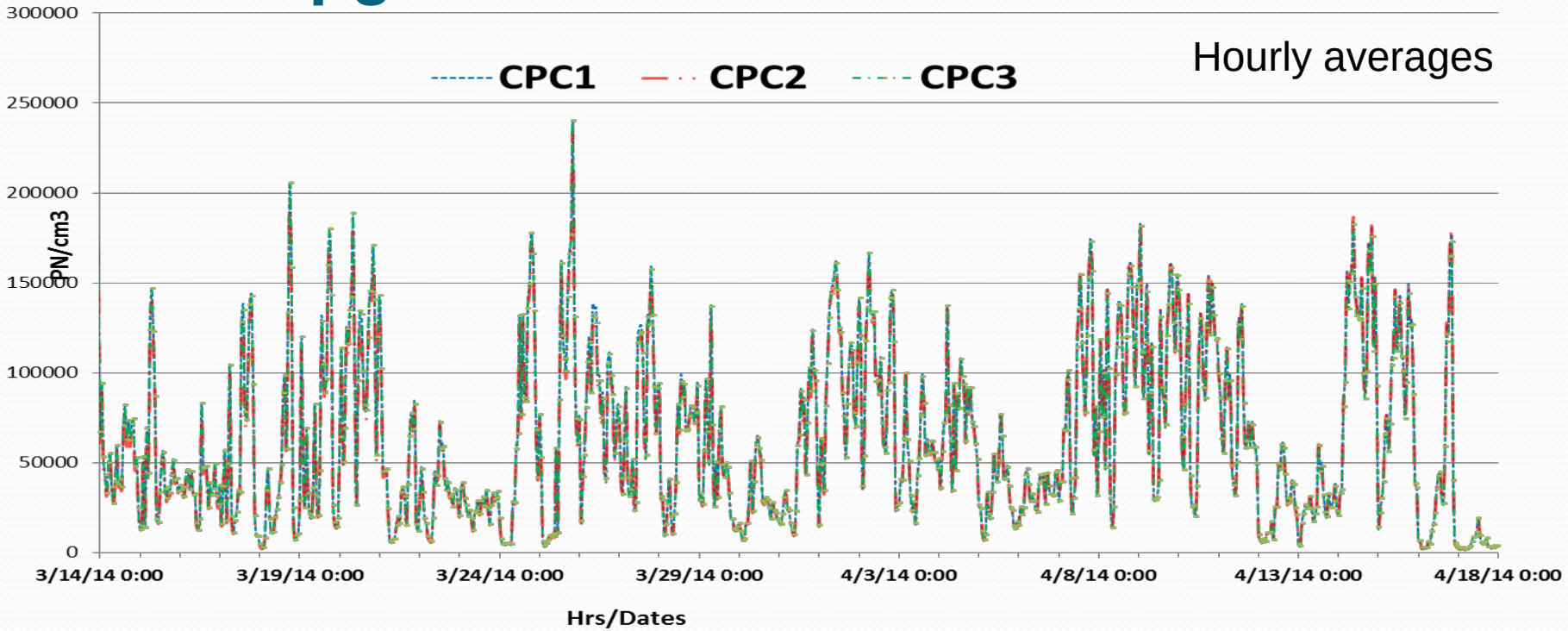


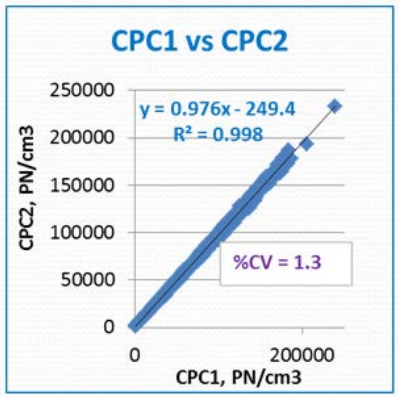
New (glass fiber)

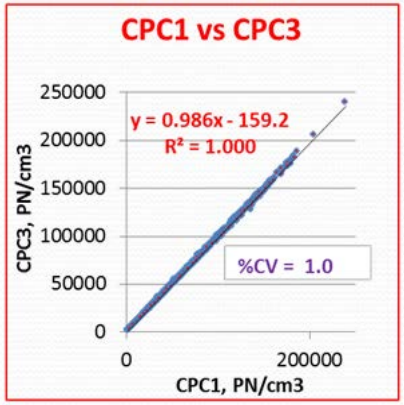
2013 Study (August 21, 2013 – April 17, 2014) Upgraded TSI 3783 Performance

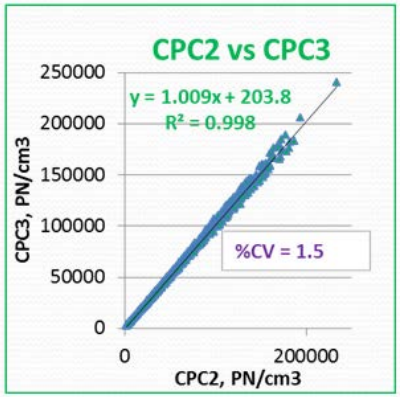
- Set-up
  - Three modified TAPI 651
  - Improved meteorological data
  - CPCs synced with ARB datalogger
- Objectives
  - Evaluate precision and durability
- *August 21 to December 31, 2013*: set-up issues (e.g. old firmware, shared pump)
  - Good durability but low precision
- *January 1 to April 17, 2014*: substantial work done to improve QA/QC procedures (e.g. new firmware, individual pumps, static dissipative tubing, consistent maintenance procedure)
  - Optimal configuration resulted in reduced intra-model variability

2013 Study (August 21, 2013 – April 17, 2014)
Upgraded TSI 3783 Performance



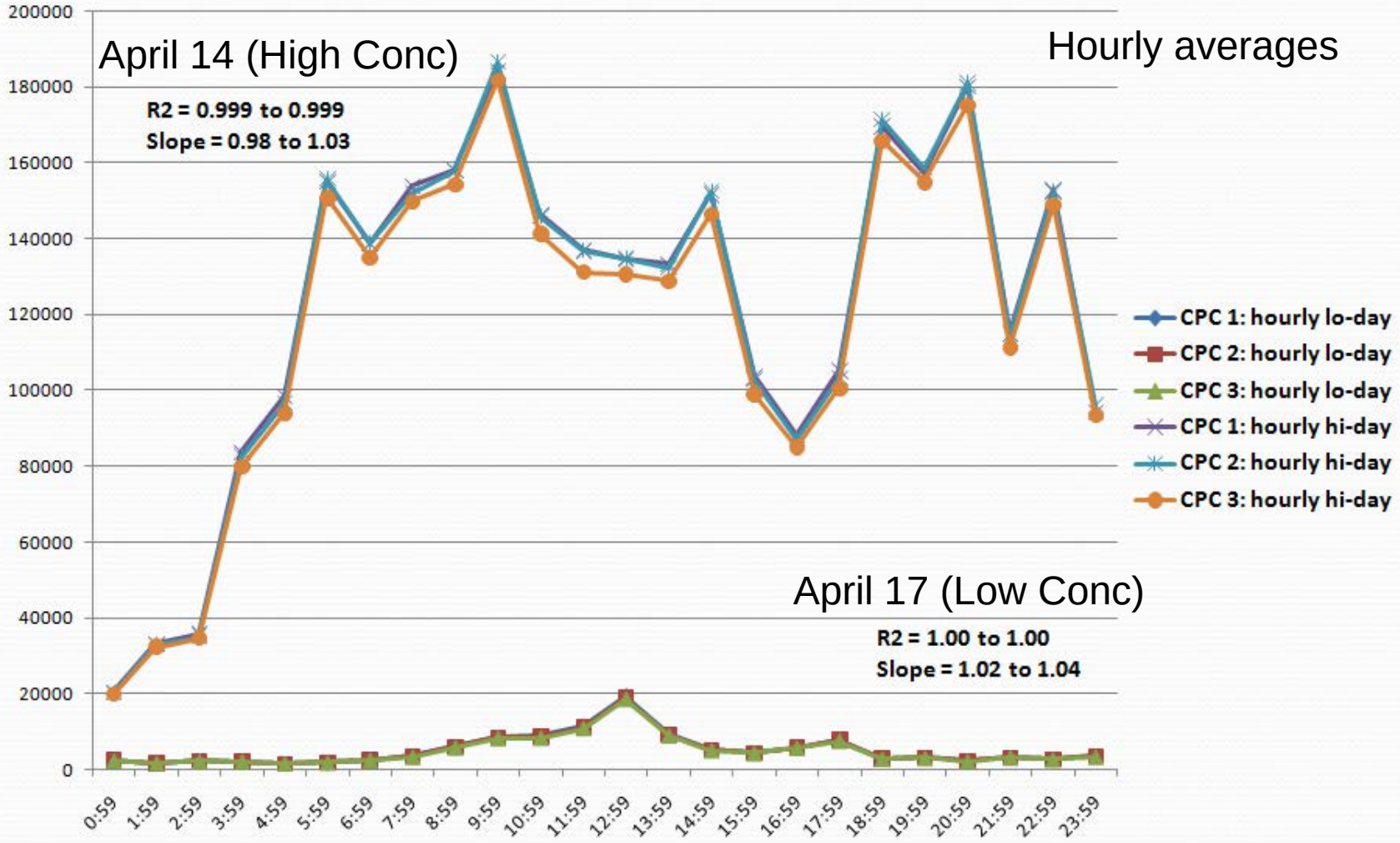




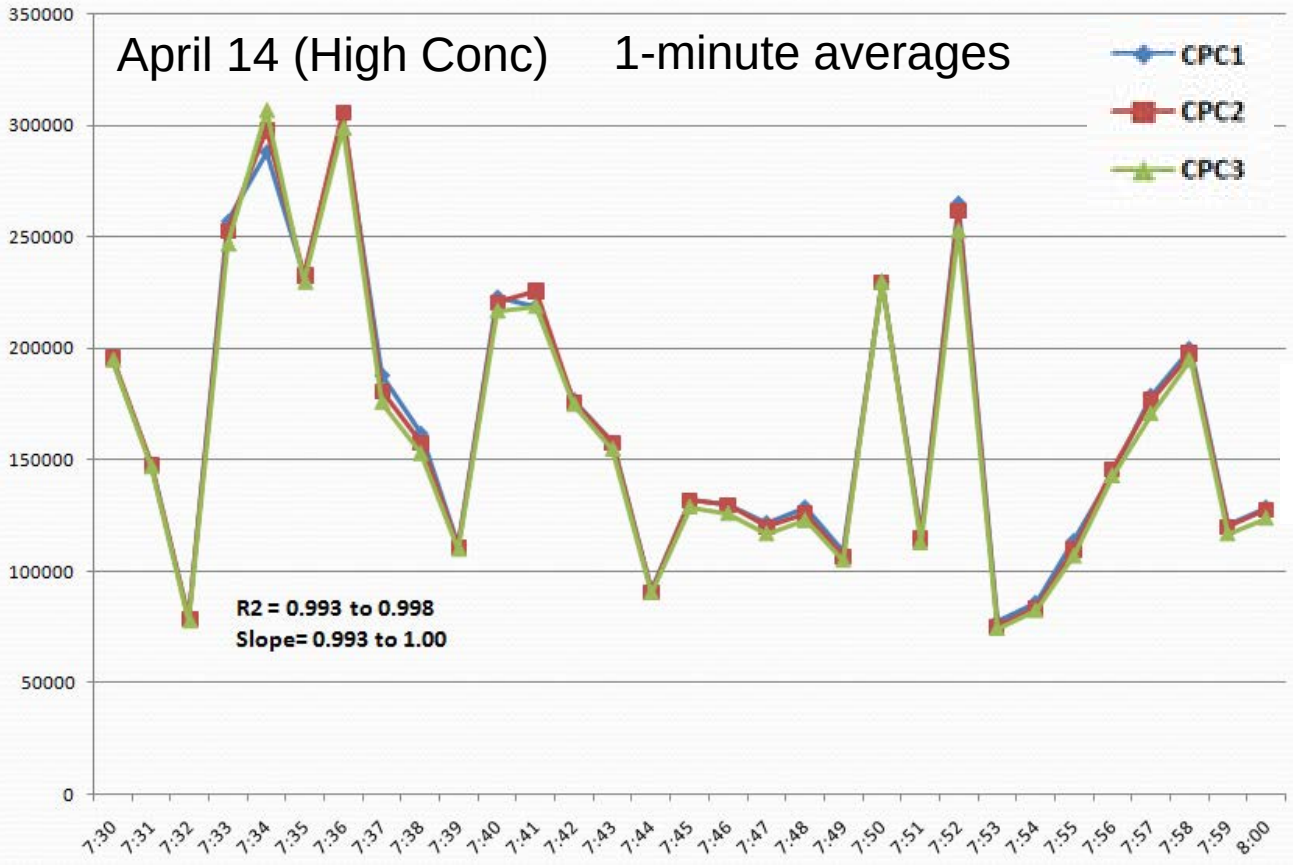


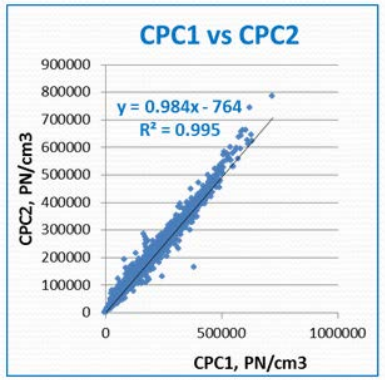
- **%CV = Upper bound coefficient of variation; U.S. EPA criteria at network level for PM2.5 is 10%**

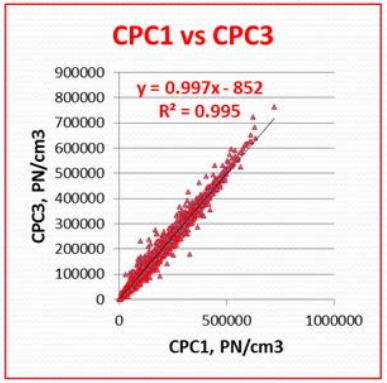
2013 Study (August 21, 2013 – April 17, 2014) Upgraded 3783 Performance

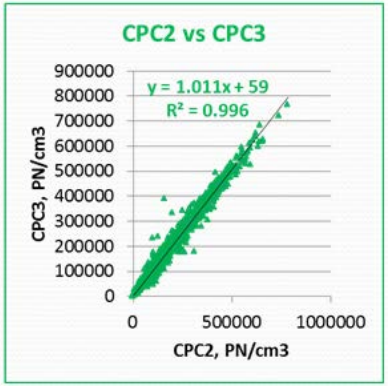


2013 Study (August 21, 2013 – April 17, 2014) Upgraded 3783 Performance









- Excellent correlation even for 1-minute data between March 14 and April 17, 2014

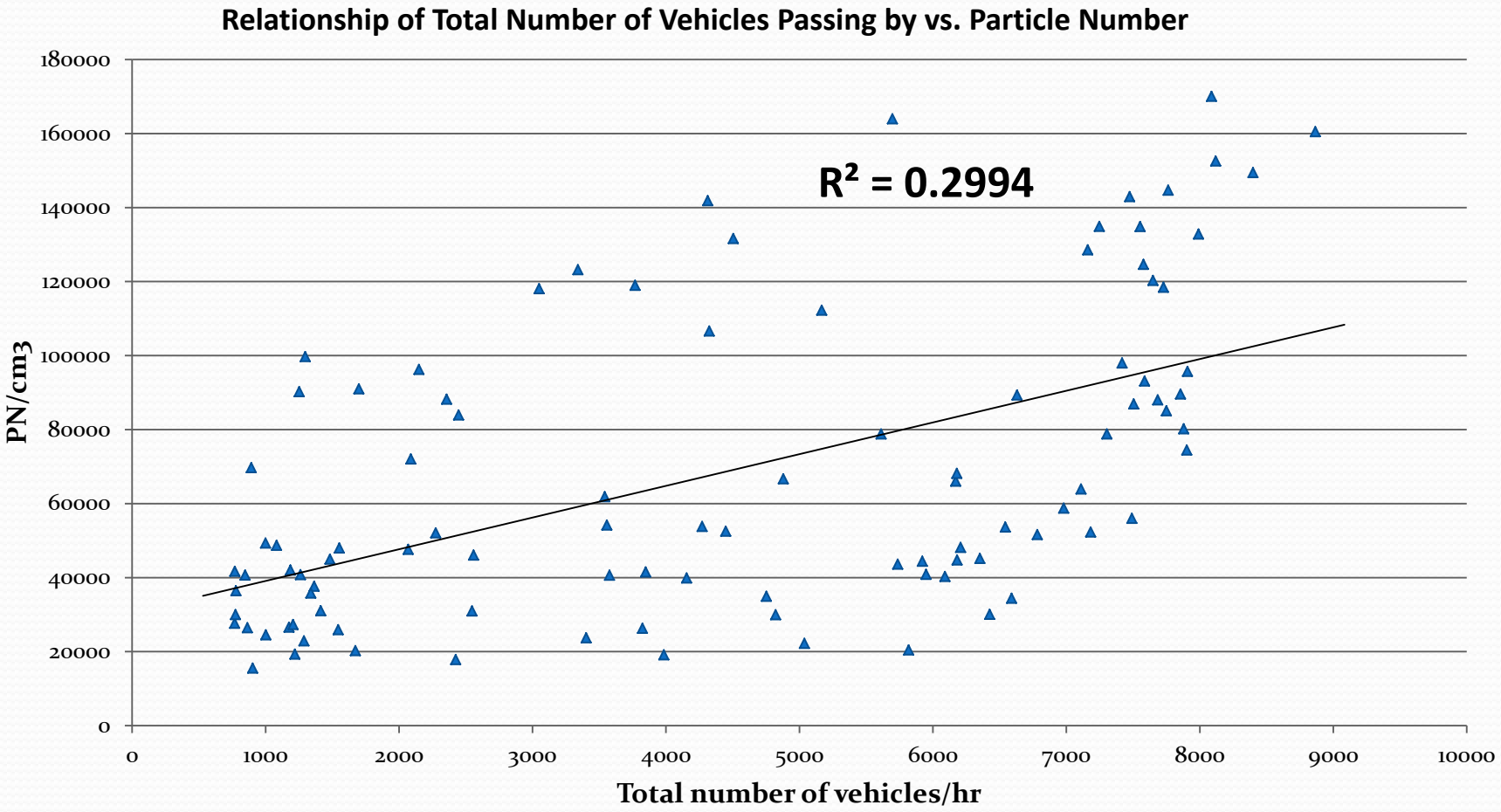
2013 Study (August 21, 2013 – April 17, 2014) Upgraded 3783 Performance

Lessons Learned – QA/QC

- Monthly cyclone cleaning is sufficient even at highly polluted locations
- Turn off vacuum pump when replacing wicks and performing inlet cleaning
- Service vacuum pump every year and provide backup pump at site
- Use datalogger when operating CPCs:
  - Time synchronization
  - Prompt review of diagnostic and PN data
- Periodic collocation with an independent CPC is recommended (no calibration standard available)

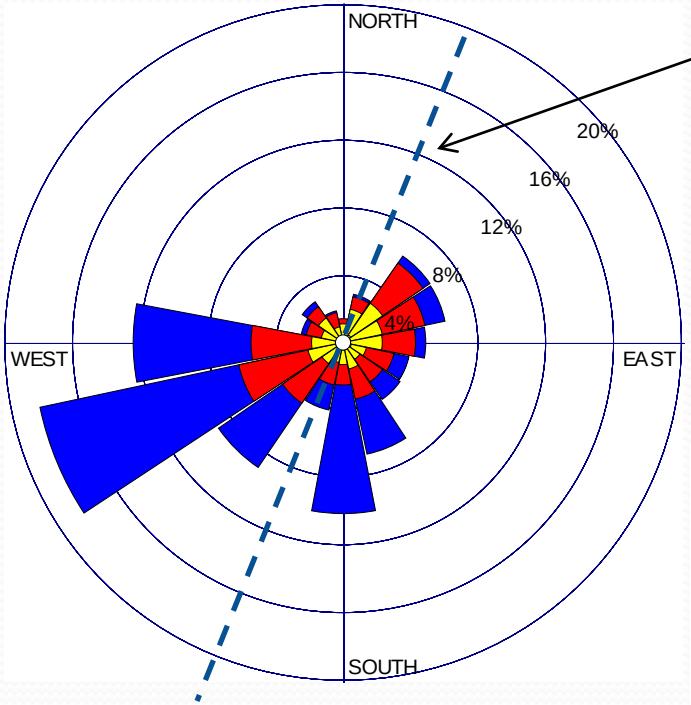
➢ *An SOP summarizing these QA/QC checks is available*

All Vehicles vs. PN – All Lanes



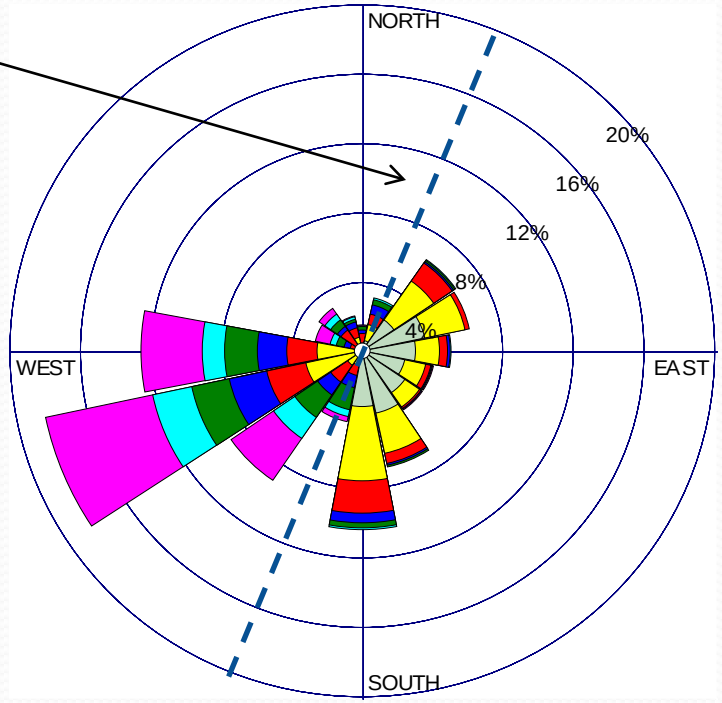
Wind Rose Plots I-710 freeway

Hourly Average Wind Speed/Direction



1-710

Hourly Average Pollution Concentration/Direction

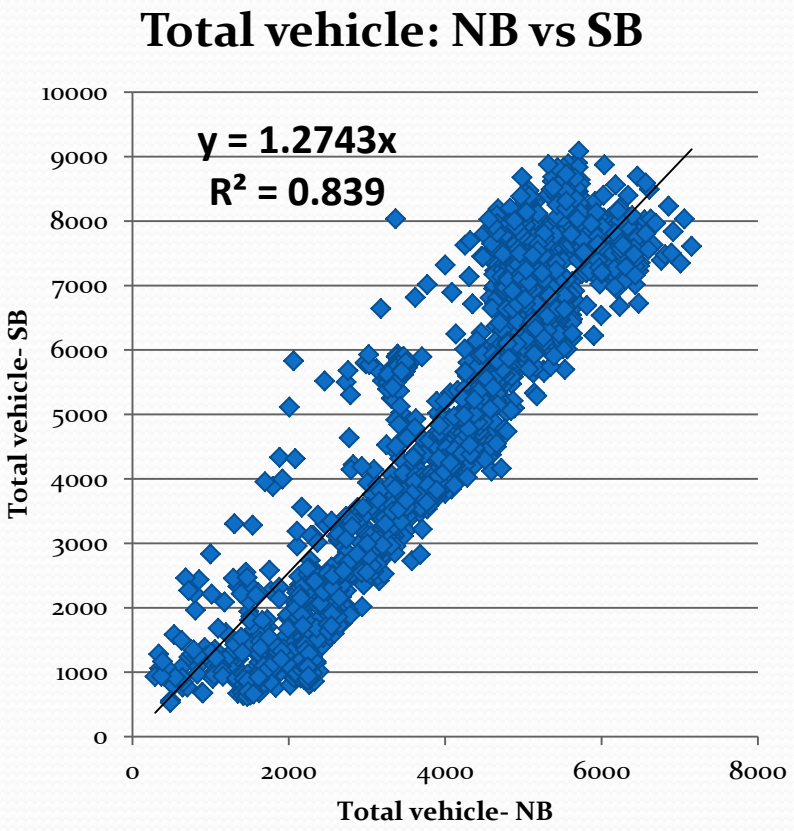


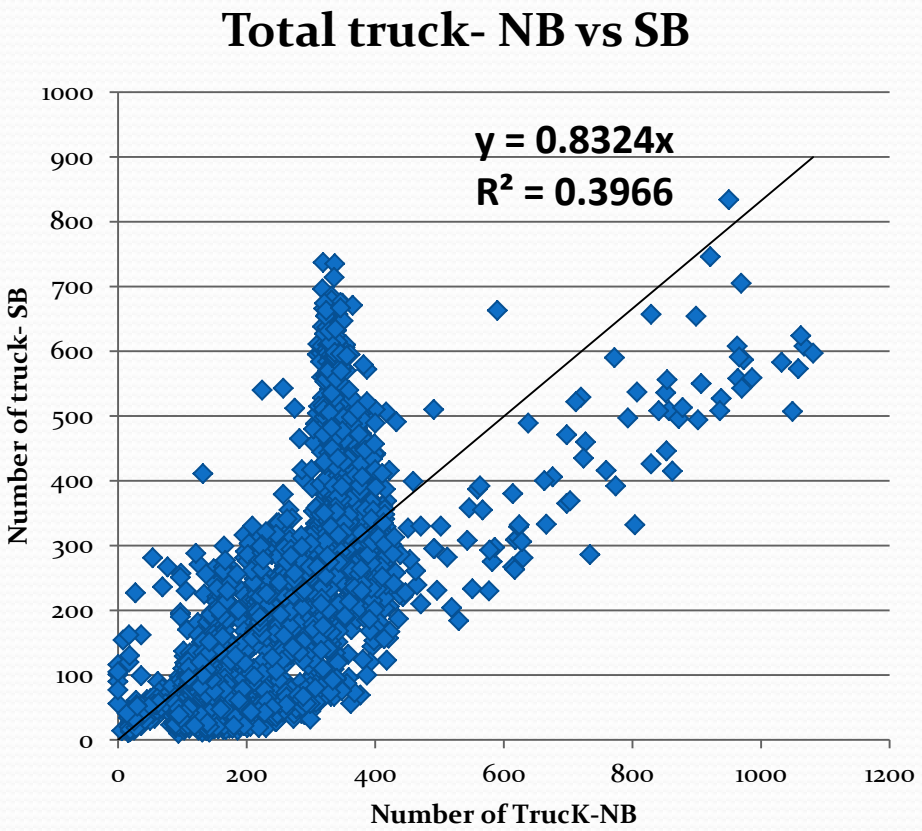
CPC (x1000)

Calms: 2.01%

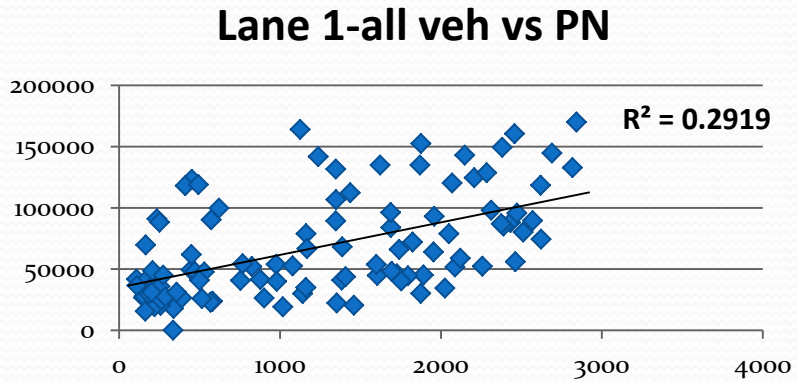
Zero

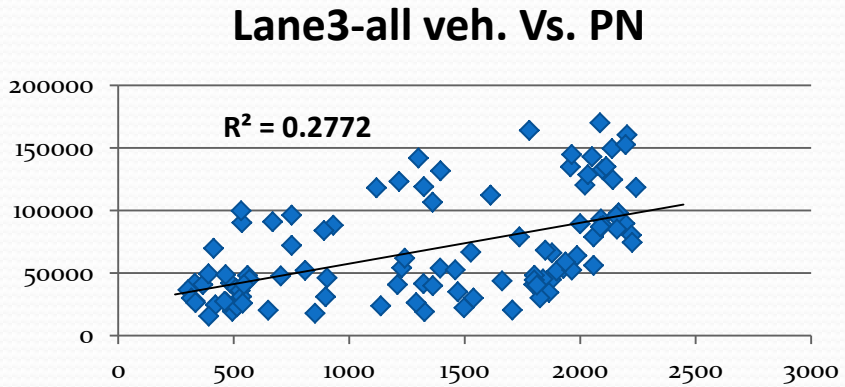
Northbound vs. Southbound

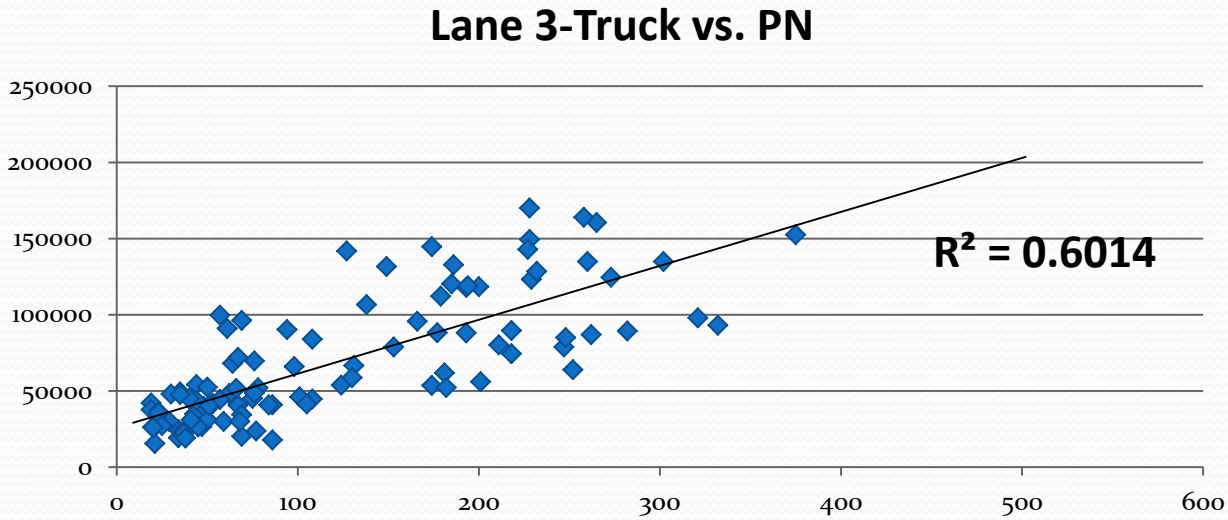




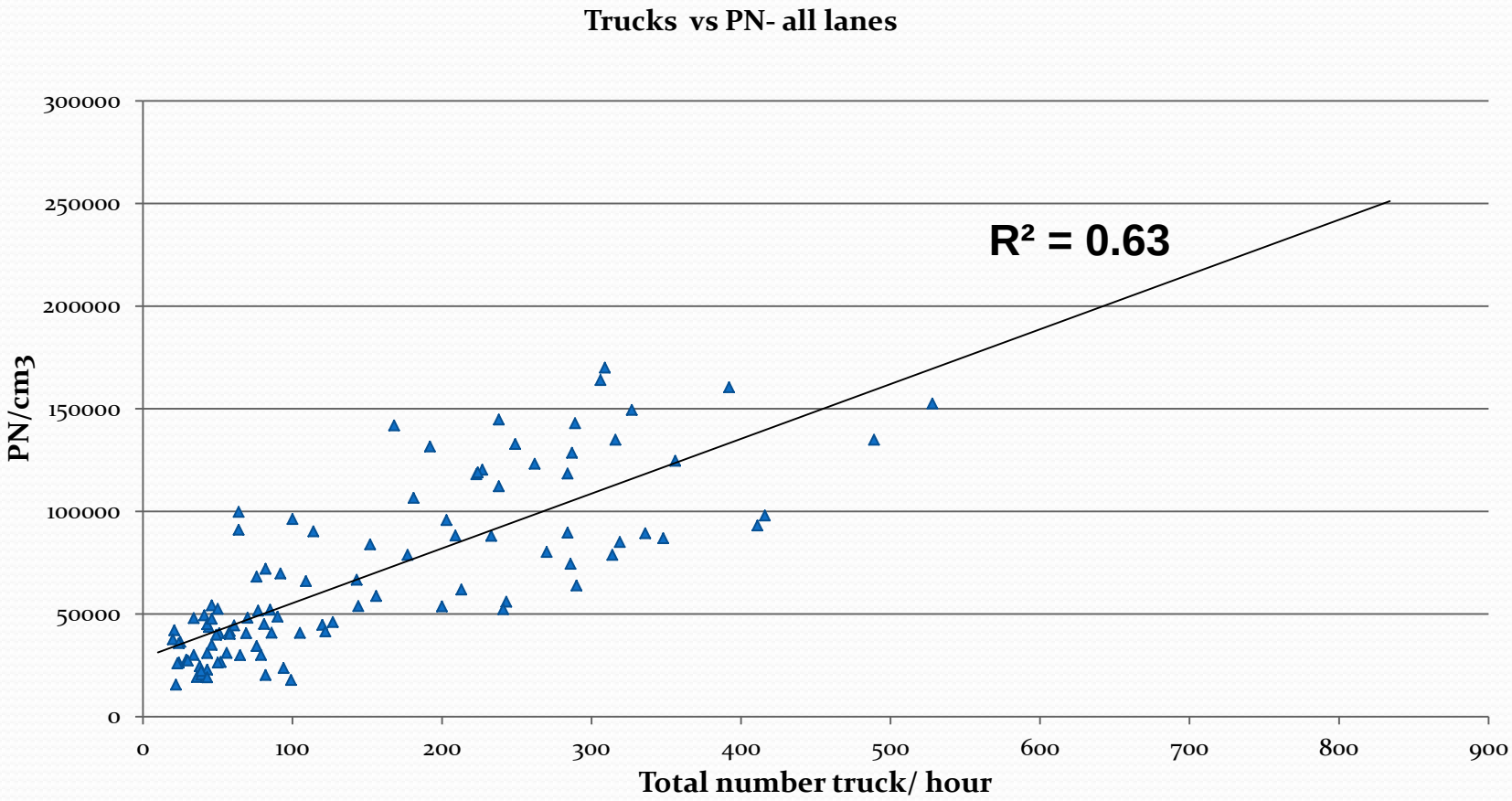
Vehicle Number vs. PN by Lane







Trucks vs. PN – All Lanes (NB+SB)



2013 Study (August 21, 2013 – April 17, 2014) Upgraded TSI 3783 Performance

Conclusions

- When proper QA/QC practices are followed the 3783 operates reliably for extended periods of time. >75% data capture can be expected. Meets the criteria for ambient air monitoring networks
- Better correlations of truck counts vs. PN compared to total vehicles counts vs. PN support the previous findings that overall on-highway diesel engines release more UFP compared to non-diesel engines in urban environments.
- Combining vehicle type traffic count information with real time PN provides a robust data set to assist regulators and researchers with better understanding of population exposure to ultrafine PN.

Acknowledgement

Monitoring

- Johanna Garcia (ARB)
- Adolfo Garcia (ARB)
- Phil Wagner (ARB)
- Michael Koch (SCAQMD)
- Eric Holden (TAPI)
- Maynard Havlicek (TSI)

Data Support

- Matthew Vona (ARB)
- Aman Bains (ARB)

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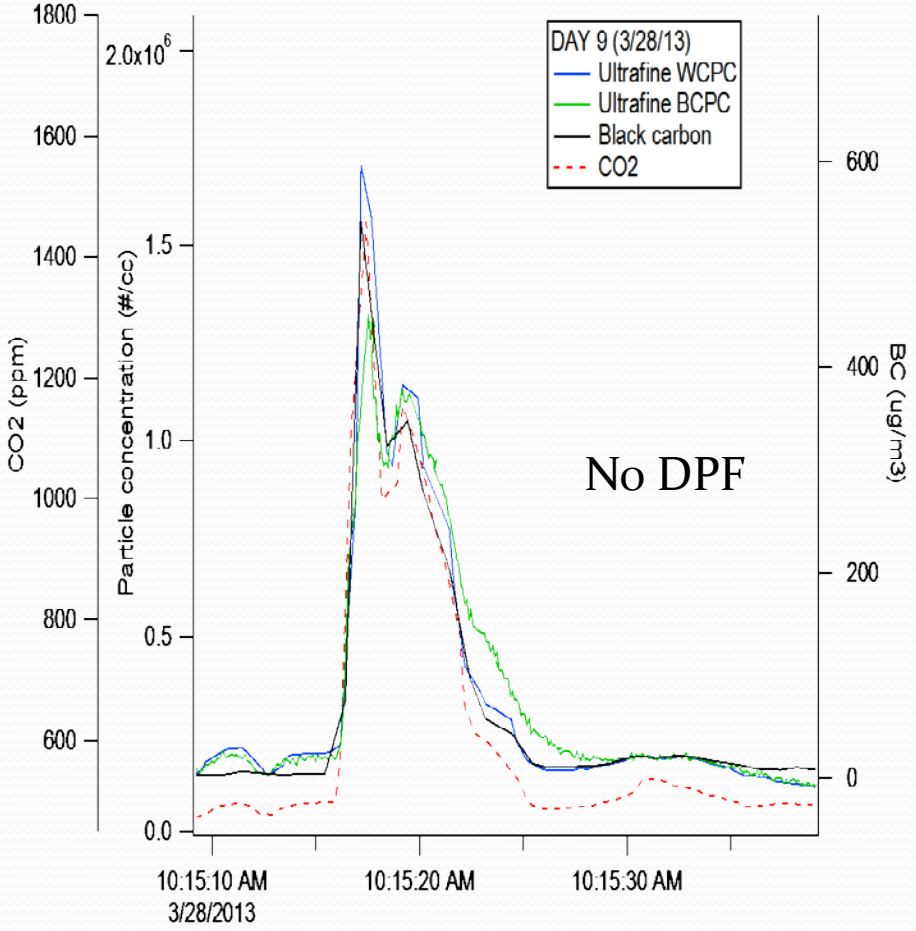
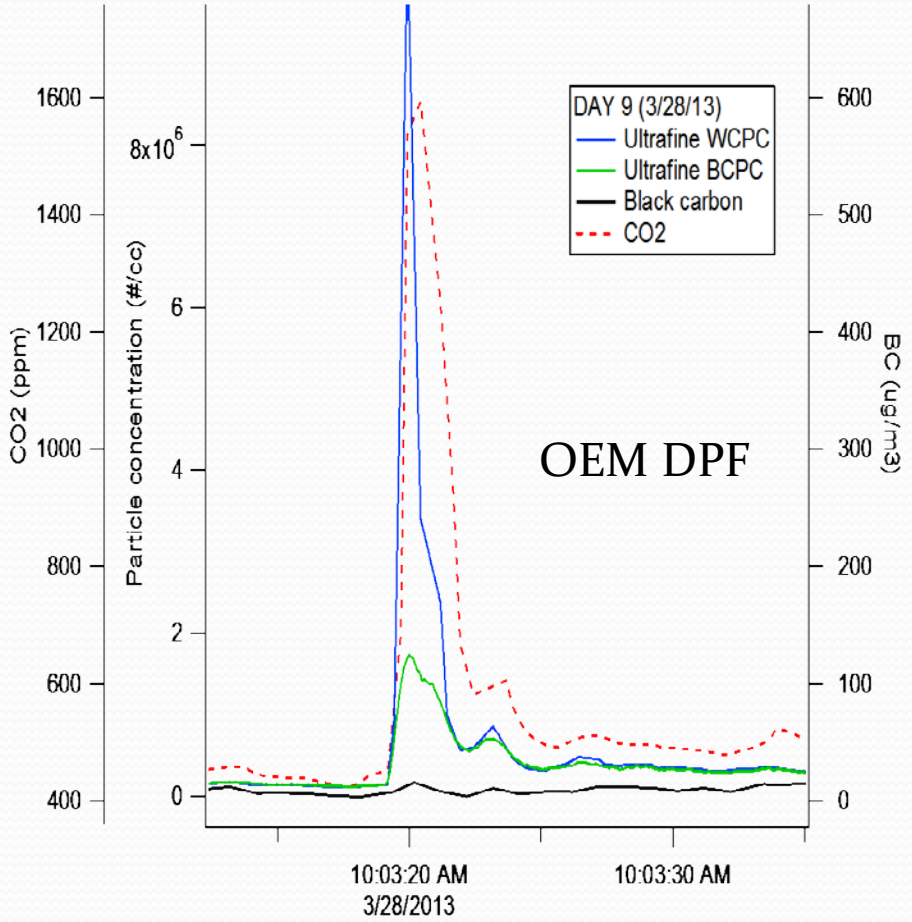
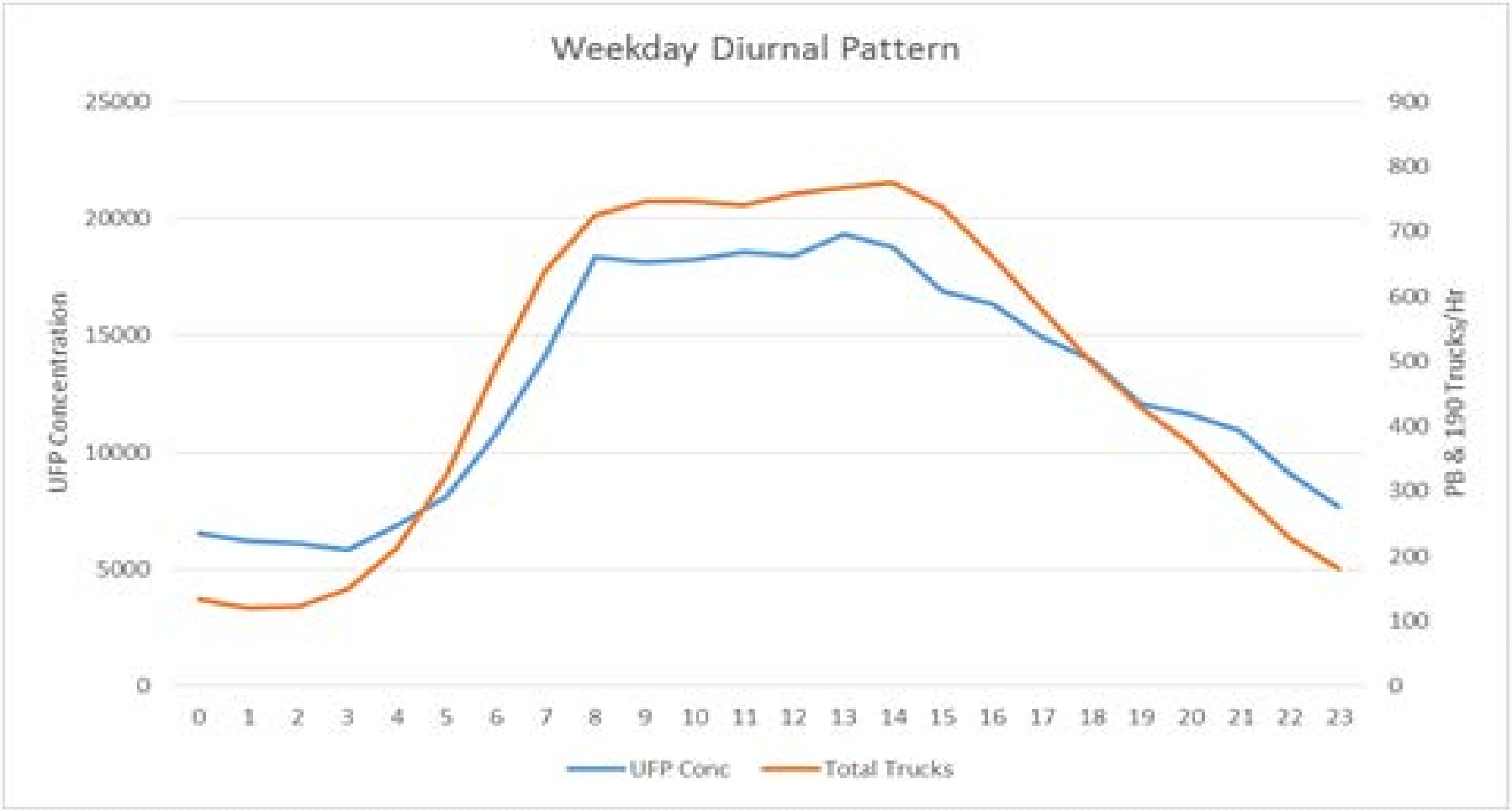
*ARB and SCAQMD participation in the study does not indicate approval or endorsement of a particular product or vendor. Any opinions, findings, conclusions, or recommendations expressed in this presentation are those of the authors and do not necessarily reflect the views of ARB or SCAQMD.

Back-up Slides


DAY 9 (3/28/13)
Ultrafine WCPC
Ultrafine BCPC
Black carbon
CO2
No DPF
CO2 (ppm)
Particle concentration (#/cc)
BC (ug/m3)
2.0x10^6
1.5
1.0
0.5
0.0
1800
1600
1400
1200
1000
800
600
600
400
200
0
10:15:10 AM
3/28/2013
10:15:20 AM
10:15:30 AM


DAY 9 (3/28/13)
Ultrafine WCPC
Ultrafine BCPC
Black carbon
CO2
OEM DPF
CO2 (ppm)
Particle concentration (#/cc)
BC (ug/m3)
8x10^6
6
4
2
0
1600
1400
1200
1000
800
600
400
600
500
400
300
200
100
0
10:03:20 AM
3/28/2013
10:03:30 AM

NYSDEC – Peace Bridge US/CAN



Weekday vs. Weekend