Performance Evaluation of a Condensation Particle Counter Near the I-710 Freeway in Southern California

Primary Quality Assurance Organization Training
Module 3: Air Monitoring Instrument Operation
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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
- Condensation Particle Counters (CPC) characterize UFP by measuring particle number (PN) concentrations
- 2010: 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
- TSI 3783 now sold as TAPI 651

Outline

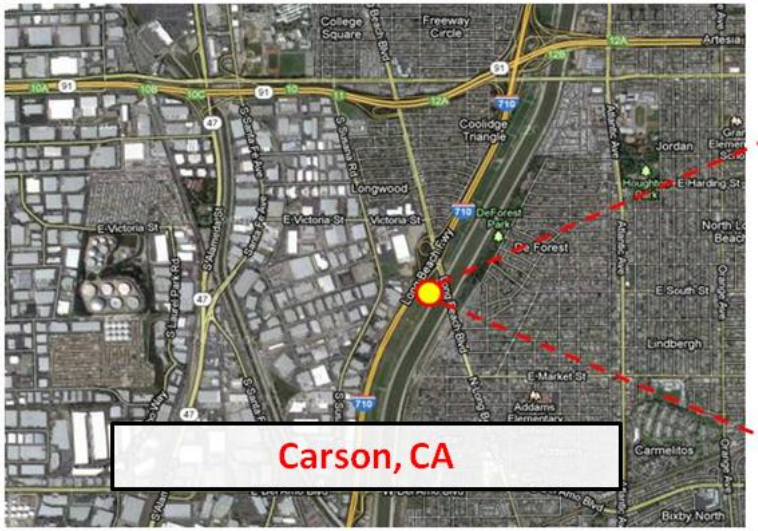
Collaboration between SCAQMD, ARB, UCLA, TSI and TAPI to study the performance reliability of the 3783 TSI model:

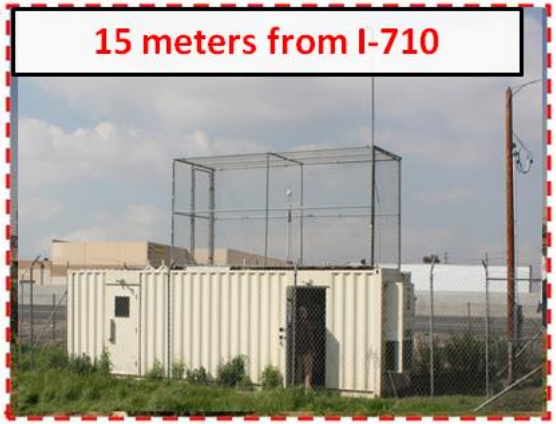
- 2011 Study (Phase I): SCAQMD, UCLA, and ARB
  - May 16 to June 14
  - Three CPC models: 3781 (x3), 3783 (x3), and 3785 (x3)
  - Inter- and Intra-model variability

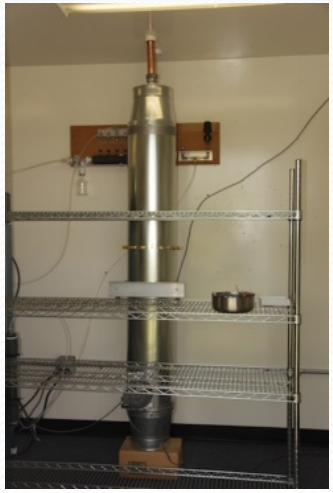
- 2011 Study (Phase II): ARB, SCAQMD, TSI, and TAPI
  - June 2011 to April 2012
  - 3783 model (x3)
  - Continued testing of durability
  - Stopped due to continual instrument breakdown

- 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





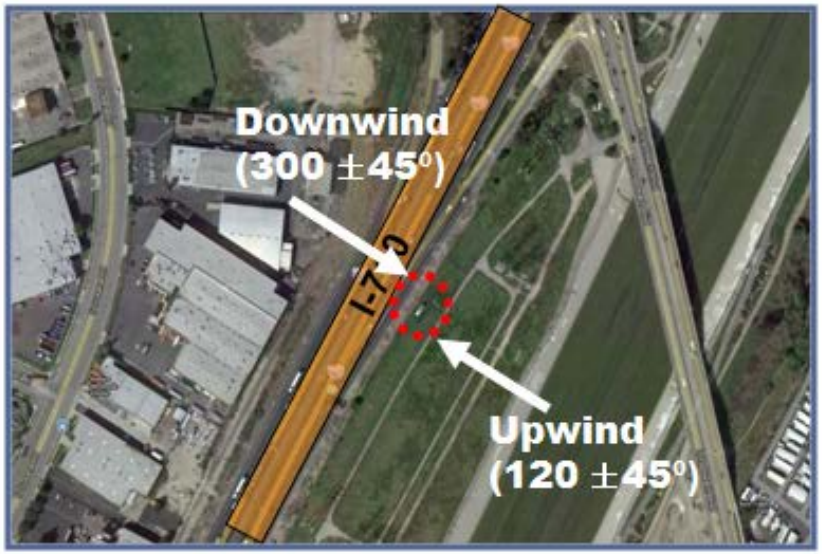


Teledyne 651	
Minimum Detectable Diameter	**7 nm**
Maximum Detectable PN (#/cm^3)	**1 x 10^6**
Particle Counting Errors	**± 10%** *at 1x10^6 /cm^3*
Aerosol Flow Rates (L/min)	**0.12 ± 0.012**

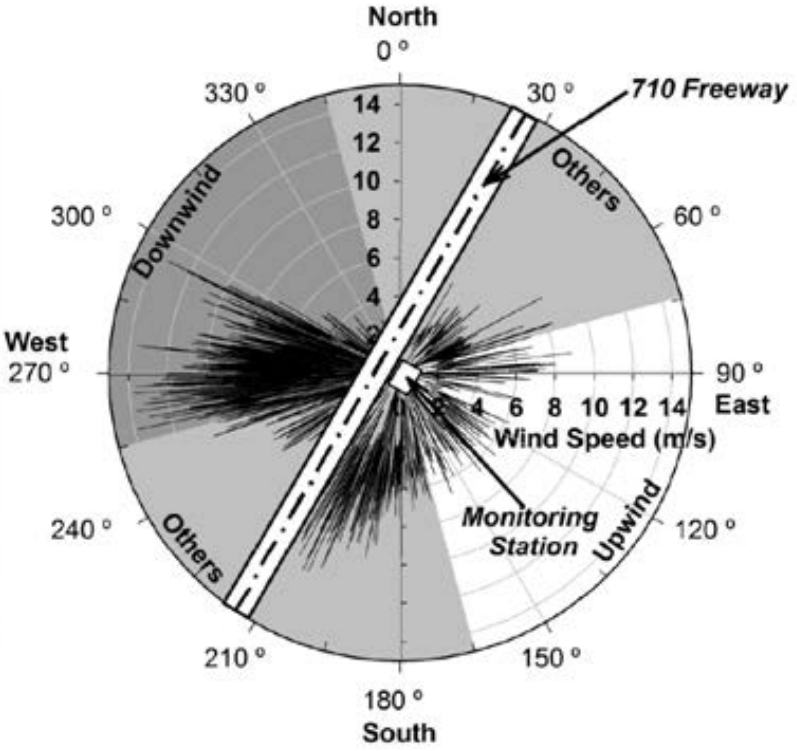
Site Location and Instrument Set-up

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

Surrounding Environment

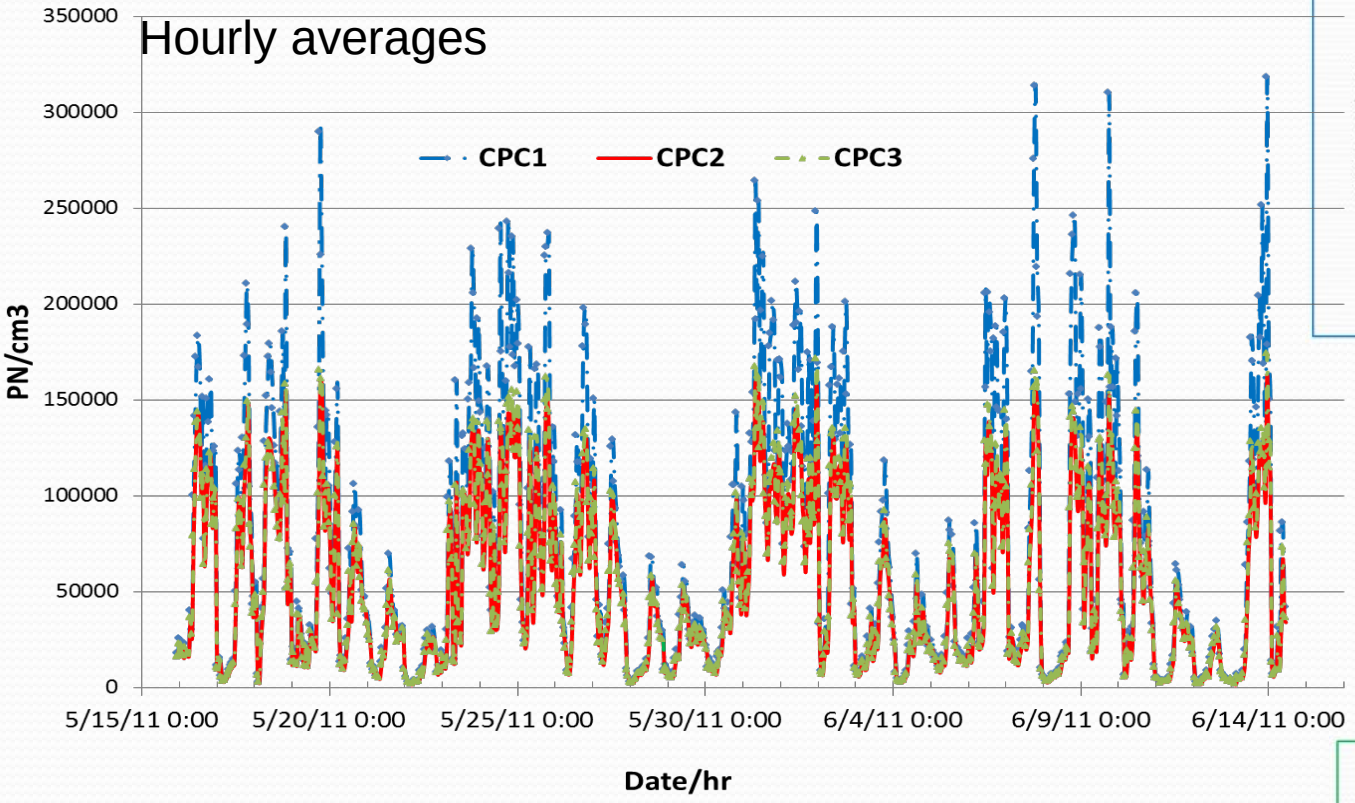


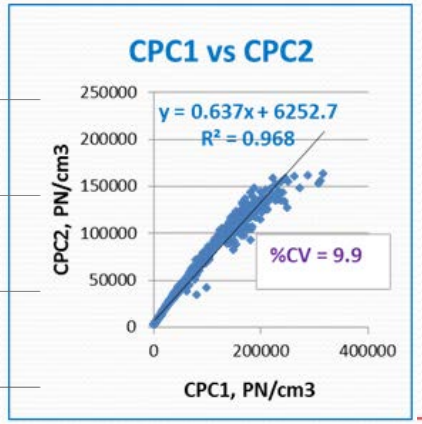
Wind Condition

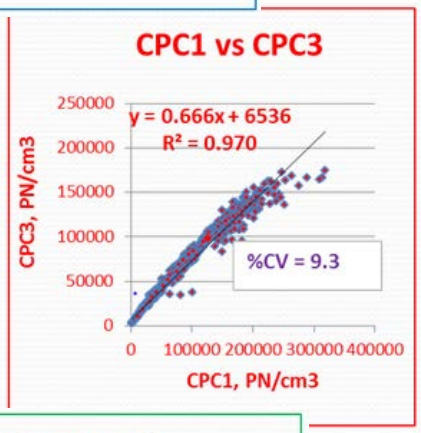


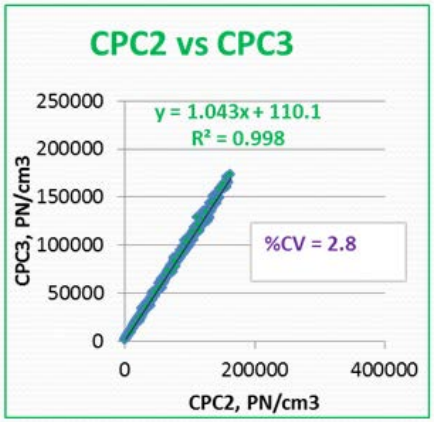
- Site is downwind of the I-710 freeway ~50% of the time

2011 Study (Phase I; May 16 - June 14)
TAPI 651 Variability







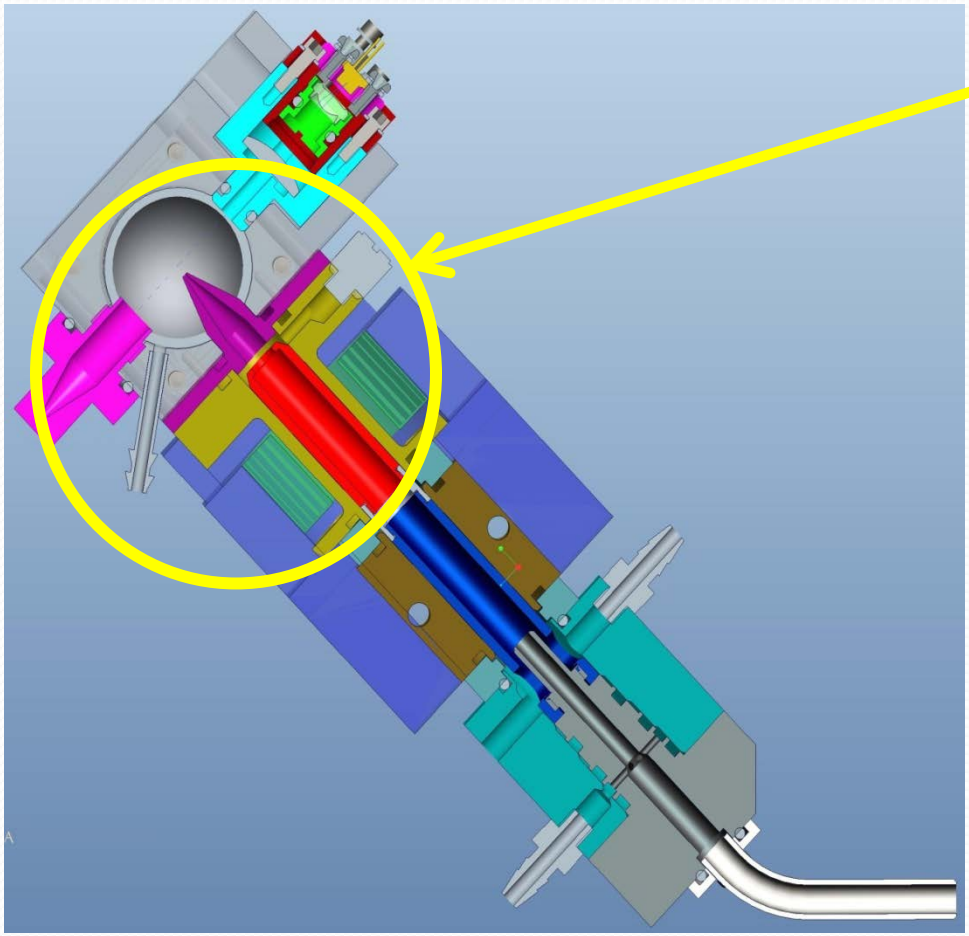


- TAPI 651 exhibited some intra-model bias
  - Two CPCs within 5%
  - Third CPC differed by ~30%

2011 Study (Phase II; June 2011 - April 2012) TAPI 651 Durability

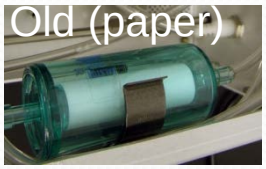
- Assessment based on continued operation of the instrument without major equipment breakdown using routine monitoring practices
- TAPI 651 unable to run for extended periods without major equipment breakdowns:
  - Flooding of the optics system
  - Pulse height out of spec (i.e. decline over time)
  - Clock drift
  - Corrupt data files during download
- Work needed to improve instrument durability and reliability

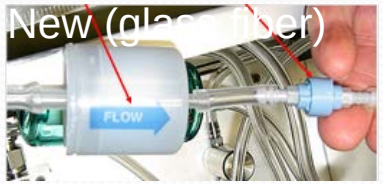
TAPI 651 Design Modifications



- Vent Assist
- Water Drain
- Longer growth tube accommodates longer wick cartridge

- New Protection Filters



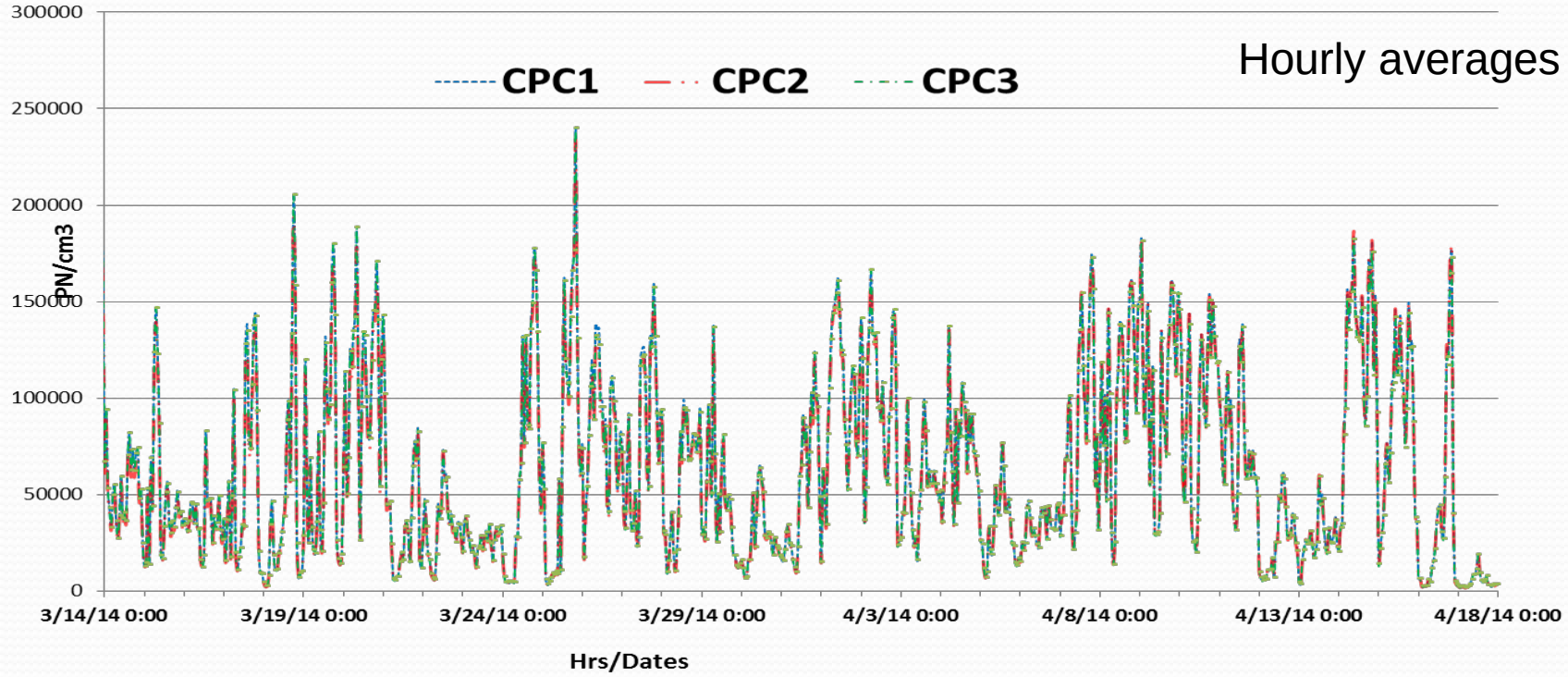


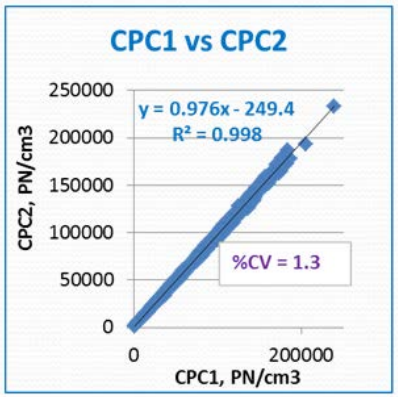
- New ejector pump for better reliability combined with lower water separator temp (7ºC vs 20ºC)

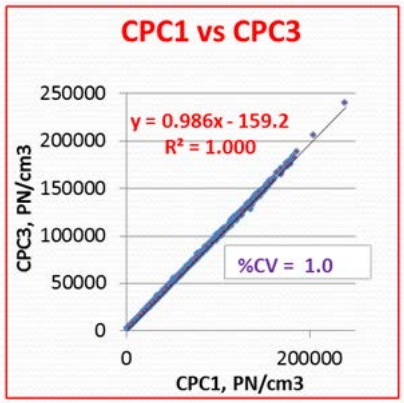
2013 Study (August 21, 2013 – April 17, 2014) Upgraded TAPI 651 Performance

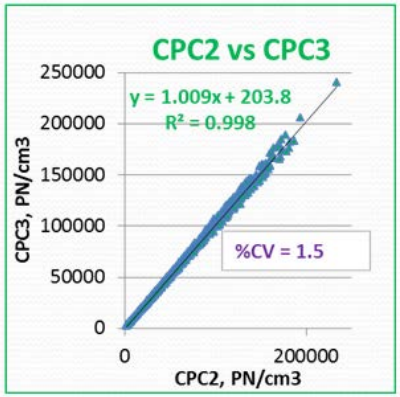
- Set-up
  - Three modified TAPI 651
  - Improved meteorological data
  - CPCs synced with CARBlogger
- Objectives
  - Evaluate precision and durability
- *August 21 to December 31, 2013*: set-up issues (e.g. old firmware, shared pump)
  - Good durability but low precision
- *January 1 to April 17, 2014*: 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

March 13, 2014 – April 17, 2014
Upgraded TAPI 651 Performance



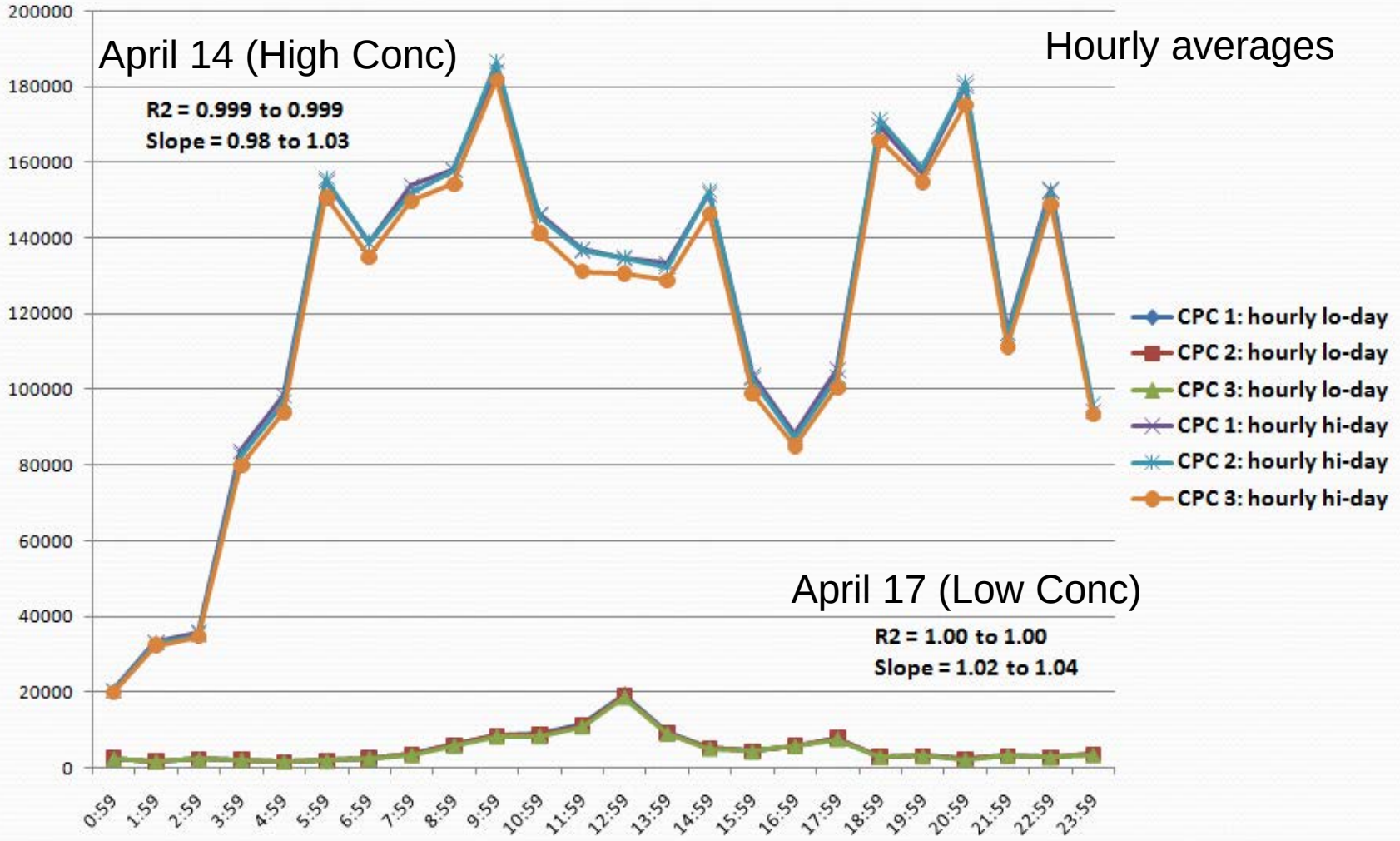




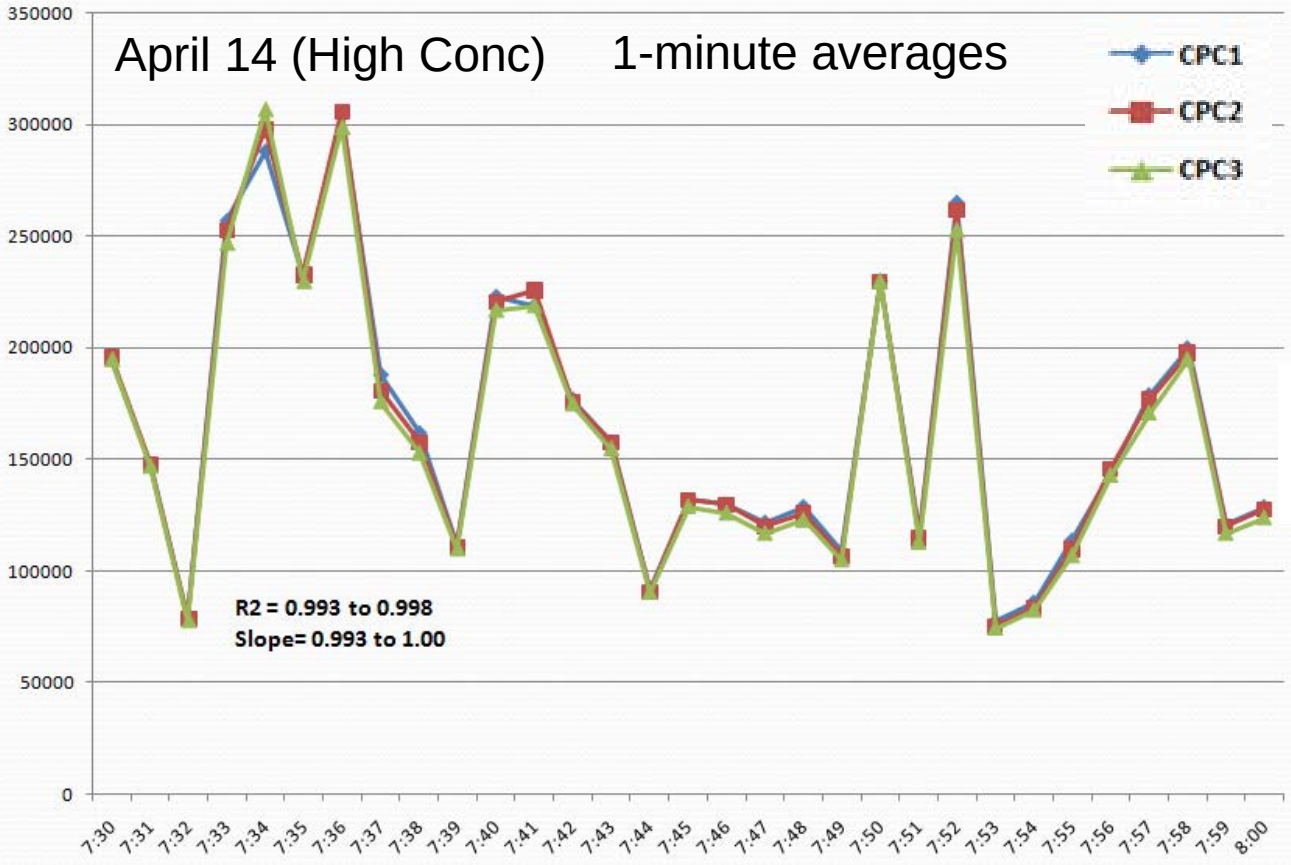


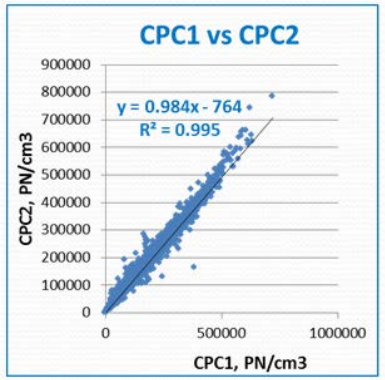
- %CV = Upper bound coefficient of variation; U.S. EPA criteria at network level for PM2.5 is 10%

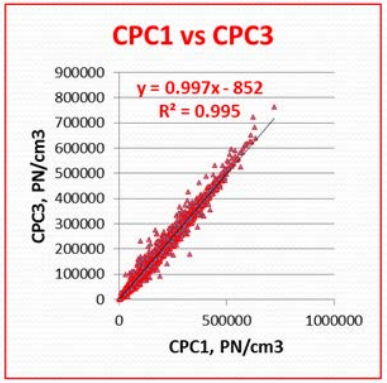
March 13, 2014 – April 17, 2014
Upgraded TAPI 651 Performance

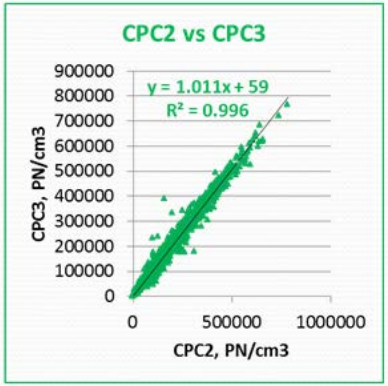


March 13, 2014 – April 17, 2014
Upgraded TAPI 651 Performance









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

March 13, 2014 – April 17, 2014
Upgraded TAPI 651 Performance

Lessons Learned – QA/QC

- Monthly inlet 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 from Teledyne*

Conclusions

- When proper QA/QC practices are followed the TAPI 651 operates reliably for extended periods of time. >75% data capture can be expected

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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.