Analyses by Wind Direction, Time of Day, and Pairwise Correlation of the Continuous Air Monitoring Conducted by OP-FTIR at the Boundary of the Intel NM Manufacturing Facility During a State-Sponsored Study of Community Air Quality

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Presentation to the CEWG
17-June-2009

Background

- Extensive air-quality monitoring along or just beyond the boundary of the facility's campus
  - State-sponsored, State/EPA-funded study
    - 34 days of continuous air monitoring
      - Simultaneously; opposite ends of campus

Purposes of Study

- Determining possible sources of measured substances not in the scope of State study
- Follow-up study conducted to:
  - Gain realistic hypothesis about possible sources
    - Vehicle, photochemical, urban pollutants, fab operations
  - Understand the extent of mixture conditions
    - Certain toxicology effects depend on the presence of mixtures

Outline of Presentation

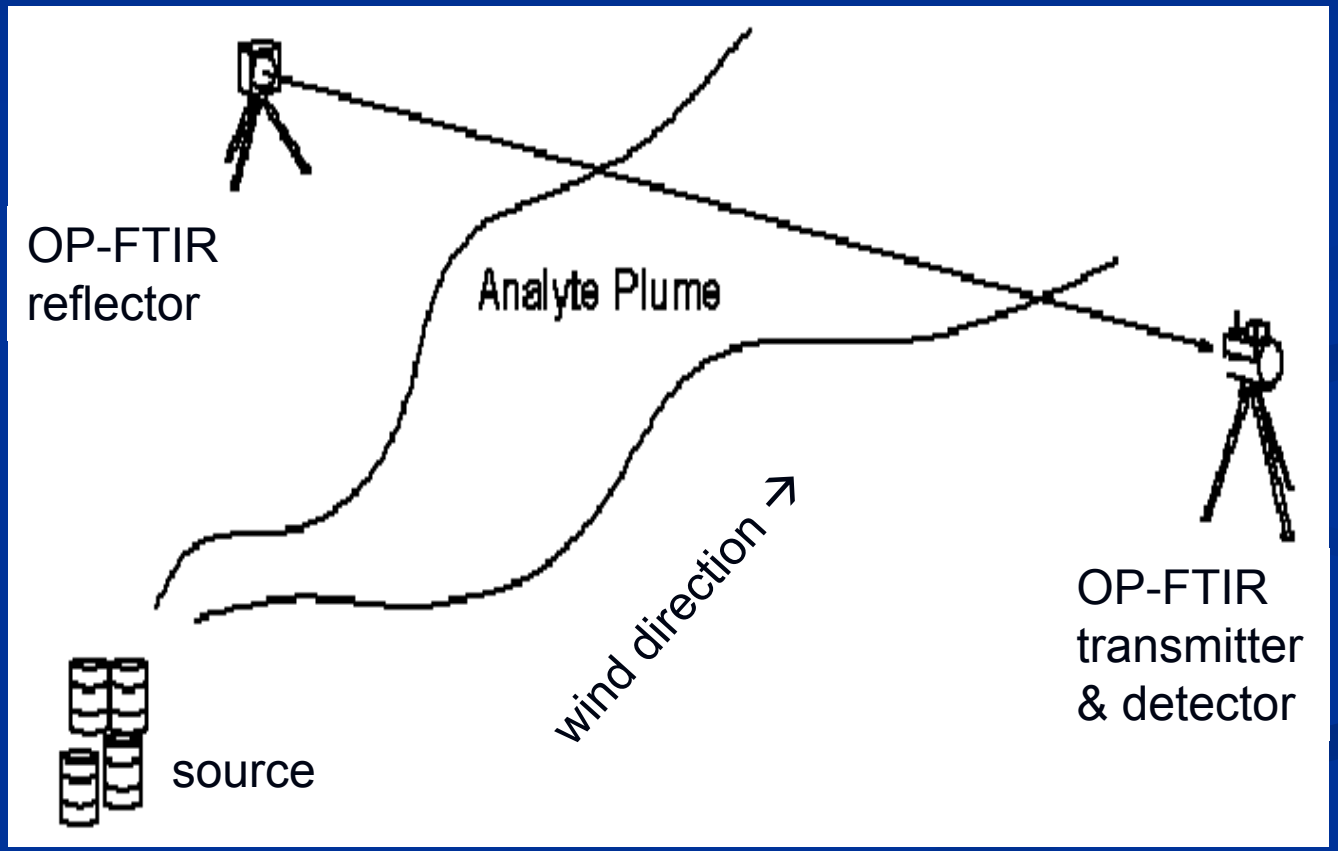
- Methods
  - Air monitoring
  - Evaluation and statistical analyses by wind direction, time of day, and pairwise correlation
- Results
- Conclusions
- Lessons learned

Methods: Air Monitoring

- Air monitoring by open-path Fourier transform infrared spectrometry (OP-FTIR)
  - Measured 45 substances, once per minute
    - 23 substances previously detected during routine testing of facility's emission stacks
  - Monitoring path lengths 200 – 220 meters
  - About 1.9 million data points
  - Minimum detection limits ≤ double-digit ppb

Methods: Air Monitoring, cont.

Simplified depiction of OP-FTIR monitoring; importance of wind direction in interpreting results.



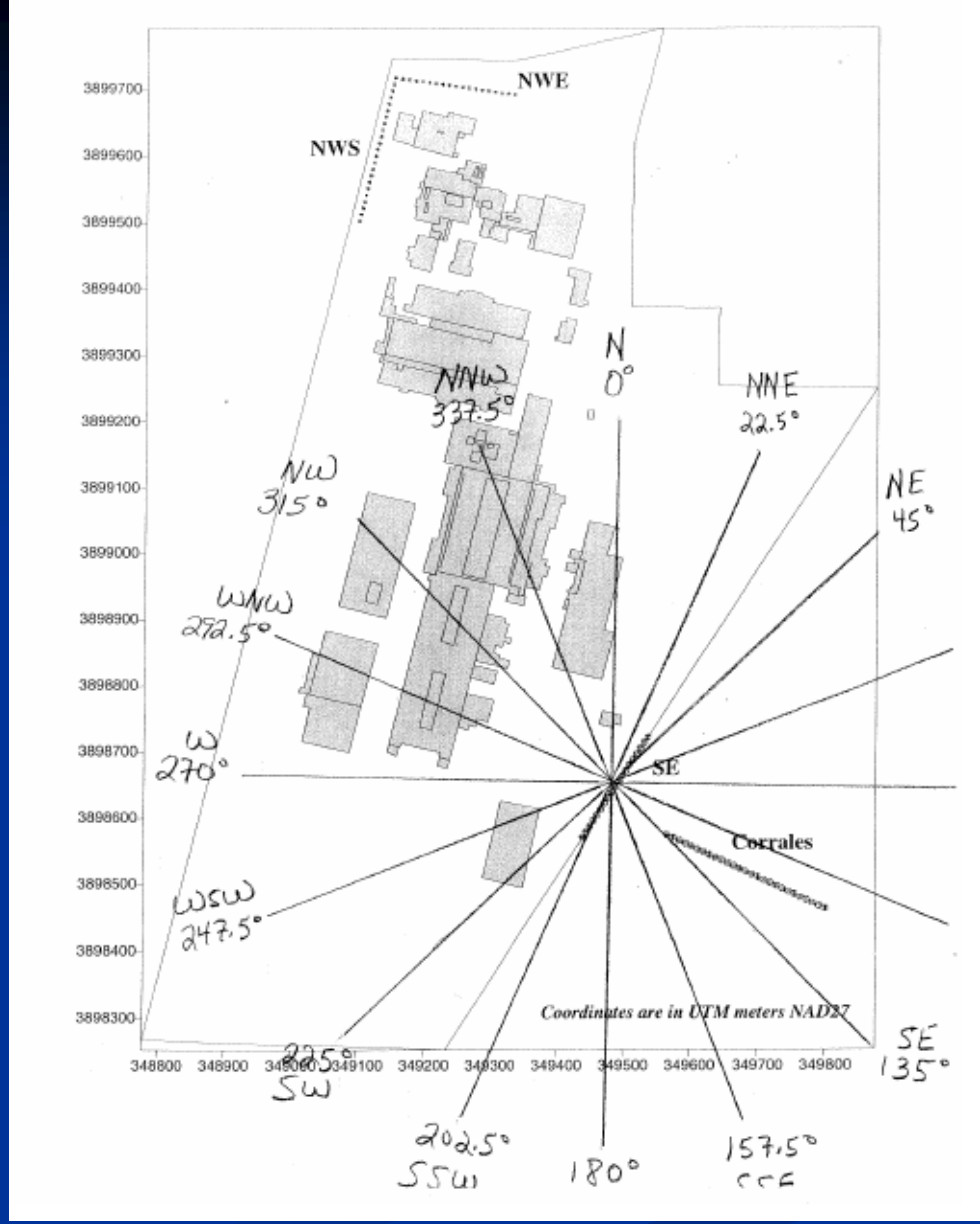
Methods: Analyses by Wind Direction

- OP-FTIR results grouped by wind direction
  - Two groups: downwind and upwind of facility
    - Number of times detected & the mean concentration of detectable events
- Local wind direction from facility's 10-m meteorological tower
  - Wind typically from many directions each day
- Statistical analyses: do differences exist between the upwind & downwind groups?

Methods: Analyses by Wind Direction, cont.

SE OP-FTIR monitoring path with compass grid to illustrate 'upwind' and 'downwind' groups based on wind direction

Downwind of facility wind directions are from W to NNE



Methods: Analyses by Time of Day and Pairwise Correlation

- Results grouped according to time of day
  - Two groups: daytime and nighttime hours
    - Number of times detected & the mean concentration of detectable events
      - Statistical analysis: differences between groups?
- Evaluate degree to which and how pairs of substances were detected simultaneously
  - Correlation coefficients, number of concurrent measurements, and concurrence as a % of the maximum possible concurrence

Results: General

- Only carbon monoxide (CO) was detected a majority of the time
  - Range 77% to 92% of the time
- The remaining substances were detected relatively infrequently
  - 3/4 of the substances were detected less than 4% of the time

Results: Wind Direction

- Almost all OP-FTIR measurements of three substances that were associated with the facility's operations were detected under downwind conditions
  - Carbon tetrafluoride (CF_4), hexafluoroethane (C_2F_6), & sulfur hexafluoride (SF_6)
    - 'Perfluorinated' substances
  - Stable, odorless, low toxicity
  - Validated the method of comparing the results of the other substances by wind direction

Results: Wind Direction, cont.

- No apparent local source ⅓ - ⅔ substances
- Facility not an apparent major contributor to the great majority of the 23 substances previously detected in ‘stack’ testing
- Facility likely was a significant source of nitrous oxide (stable, odorless, low toxicity)
- Facility a partial source of chloroform?
  - Cooling towers were a hypothetical source

Results: Time of Day

- Two substances detected more frequently and at higher concentrations during daytime hours
  - Acetaldehyde (CH_3CHO): peak detection activity corresponded to ‘rush hour’ times
    - High volume roadway borders Intel campus
  - Ozone (O_3): peak detection activity in afternoon
    - Typical for urban areas
    - Formed by photochemical reaction

Results: Pairwise Correlation

- Simultaneous detection of substances uncommon; limited presence of mixtures
  - In both absolute and relative magnitude
- Very little simultaneous detection between perfluorinated substances and the other substances
  - Additional evidence of the facility's limited contribution to the OP-FTIR measurements

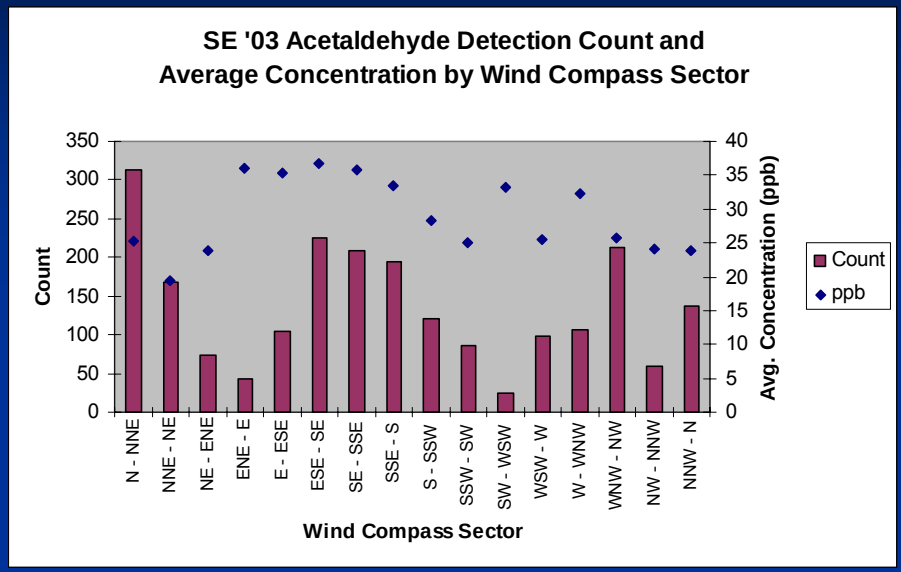
Conclusions

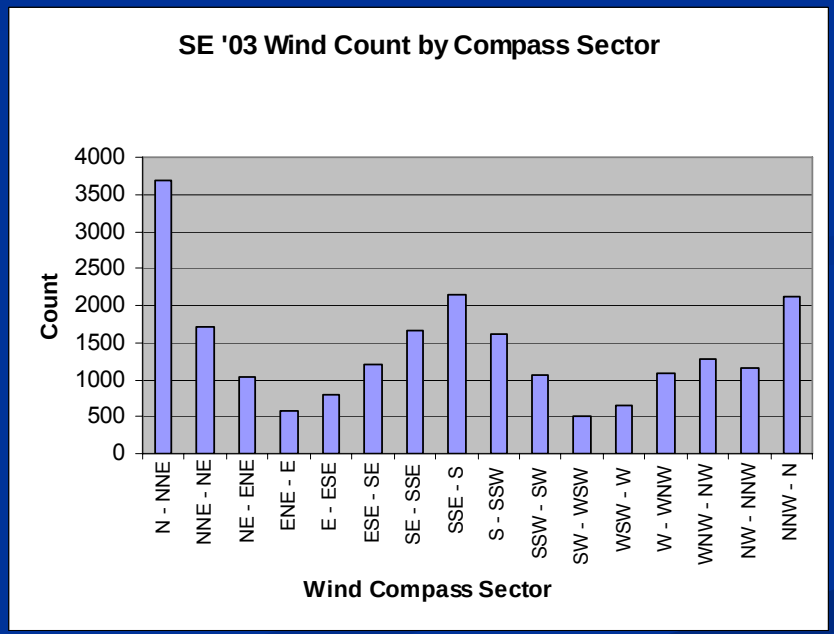
- Facility was, at most, only a partial contributor to all but a few of the substances measured by OP-FTIR
  - Regulated substances appeared to be well controlled by the emission abatement systems
- Limited presence of mixtures

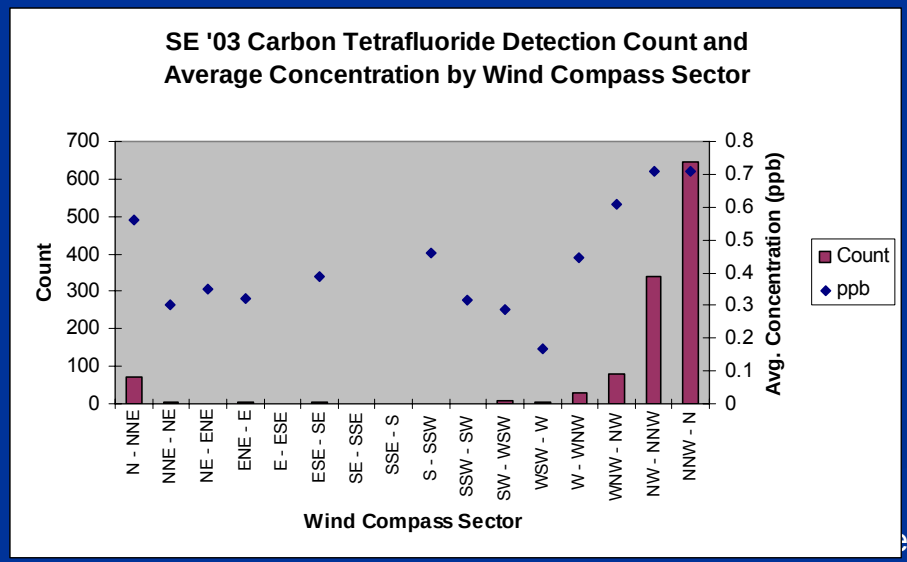
Lessons Learned

- Boundary air monitoring by OP-FTIR was involved & expensive, but resulted in:
  - A considerable amount of relevant information for assessing the health risk
  - Demonstrating that stack dispersion models are reasonably accurate and reliable
  - Generating meaningful hypotheses about sources, when evaluated by wind direction & by time of day
  - Gaining a realistic understanding about a facility's potential impact to the community

Selected Wind Direction Results







Selected Time-of-Day Results