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Probing the Properties of Particulate Pollution: Real-time Methods for Detailed Characterization

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Southern Ontario Centre for Atmospheric Aerosol Research

Acknowledgments

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- Health Canada

All results should be considered as preliminary

Conclusions do not necessarily reflect views or position of funding agencies

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Presentation Objectives

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- Illustrate the PM characteristics that can be obtained using newer real-time instruments:
  - Chemical characteristics
  - Physical characteristics
- Describe data mining strategies useful for interpreting large numbers of data

PM Chemical Characteristics

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- NAPS 24 hour filter samples
- Aerosol Mass Spectrometry (AMS)
- Single particle aerosol time of flight mass spectrometry (ATOFMS)

Off line analysis

Aerosol Mass Spectrometer

PM_1 Size Resolved Organics, NH_4^+, Cl^-, NO_3^-, SO_4^{2-}

Aerosol Time of Flight Mass Spectrometer

Size Resolved (30-3000nm) Positive and Negative Spectra Signal

Increasing time resolution

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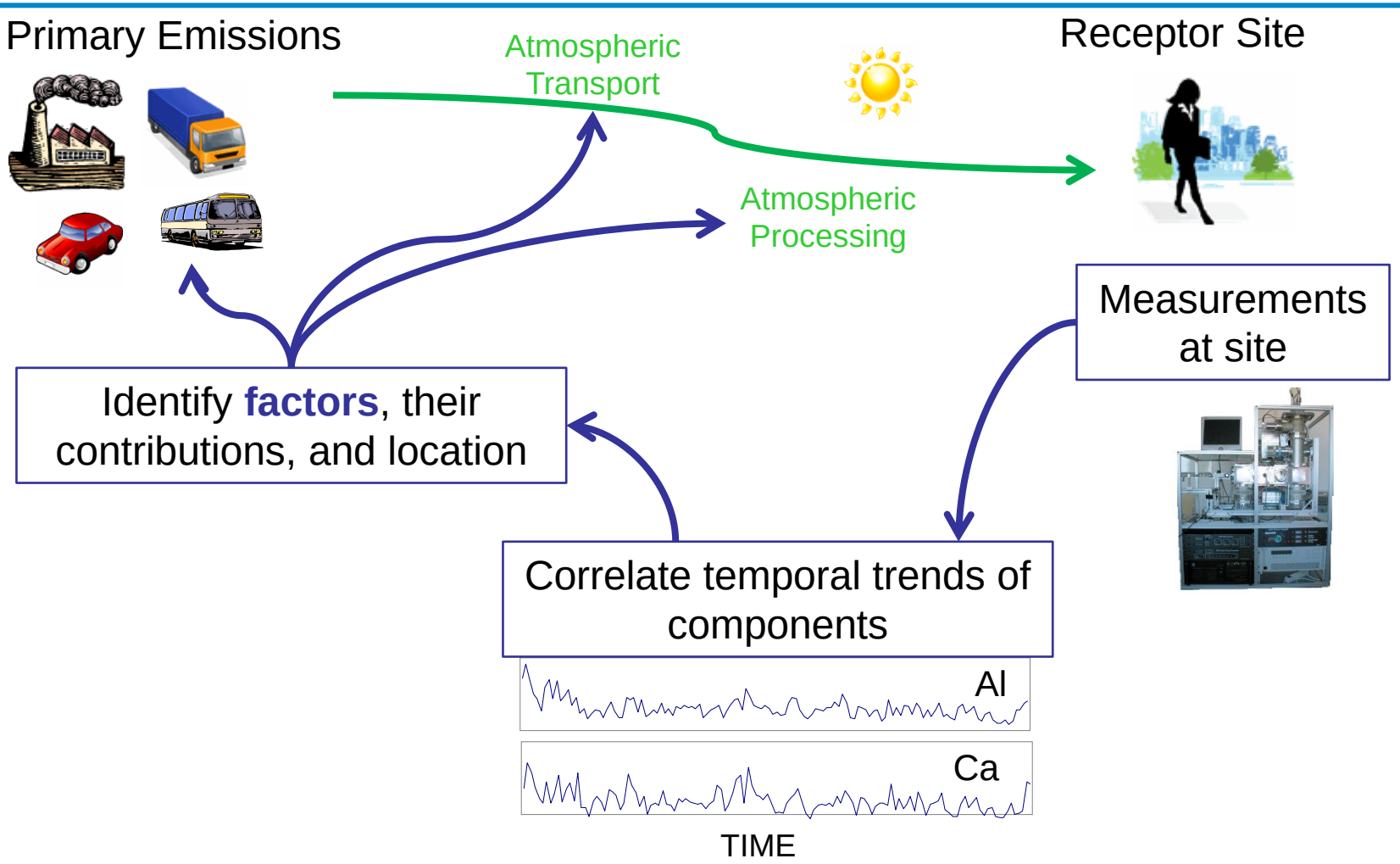
Receptor Modeling:
Positive Matrix Factorization



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Properties of Measurement vs. Receptor Modeling Results

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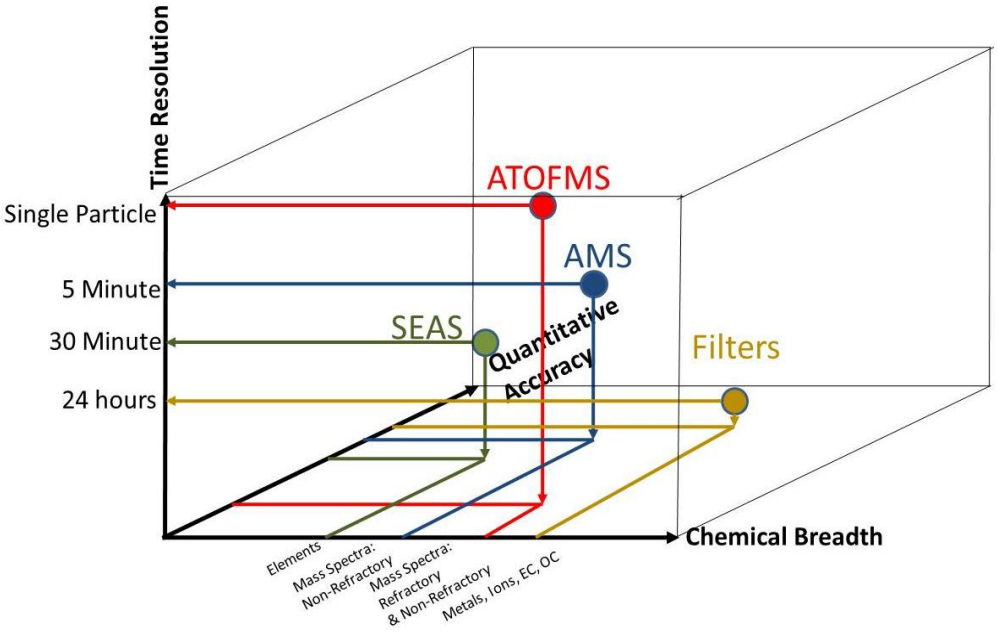

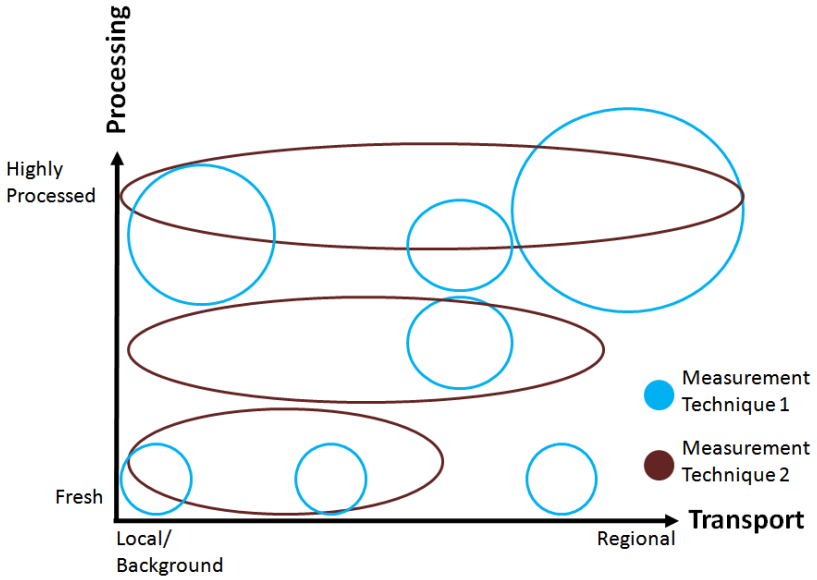

Properties of Measurement → Specificity of Factor Identification

Multivariate Receptor Model

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PMF of 24h NAPS filter samples: Windsor 2004-10

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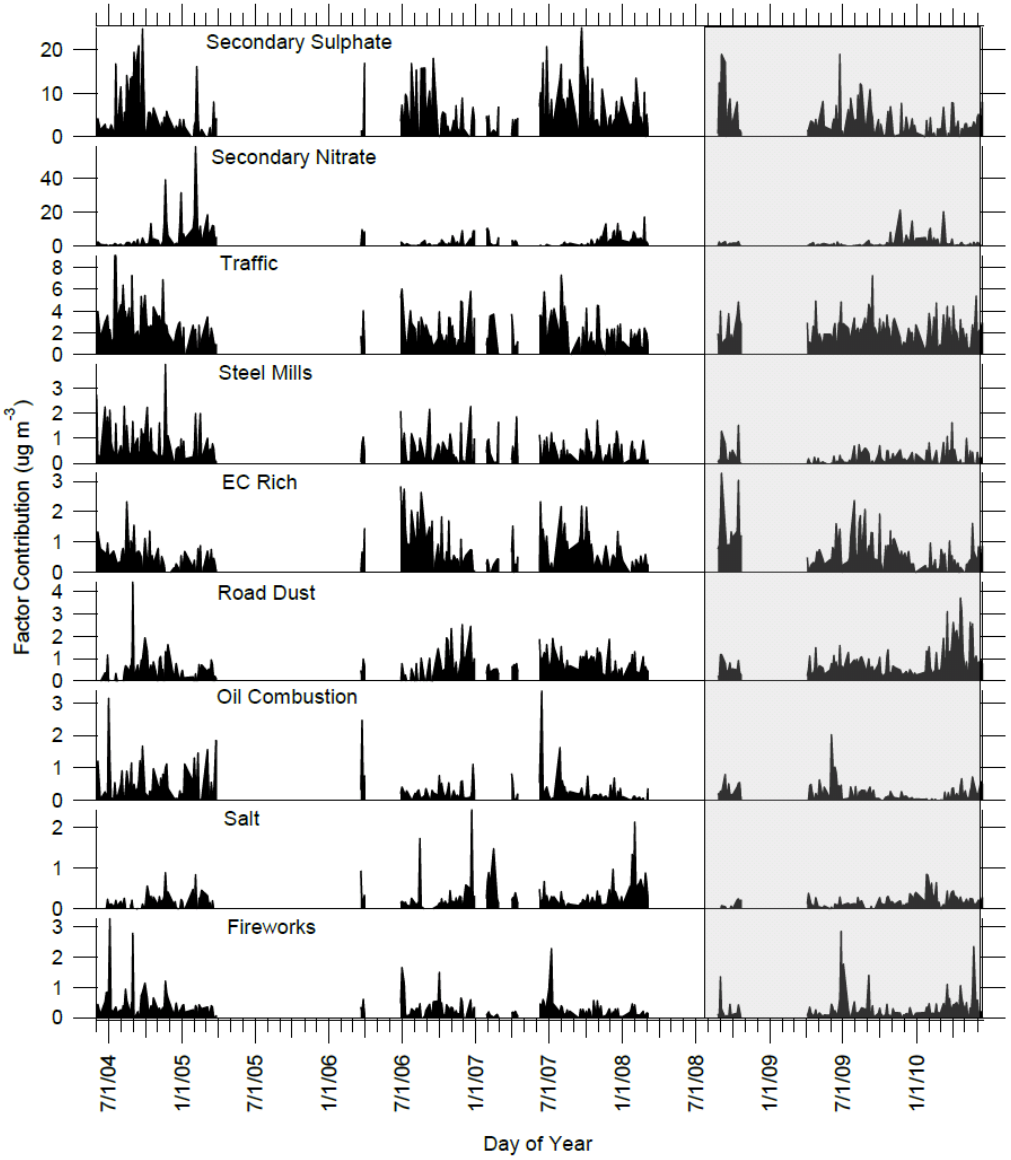
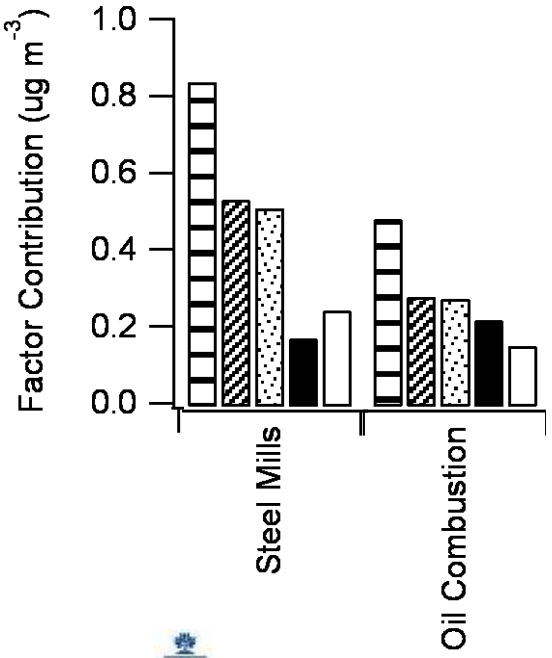


Captures long-term, seasonal, synoptic weekend, and some day-to day temporal patterns



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PMF of 24h NAPS filter samples: Windsor 2004-10

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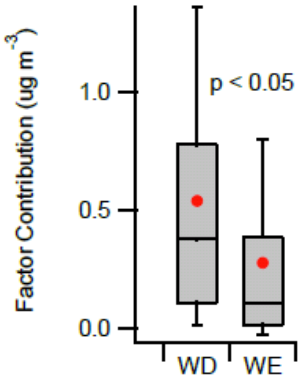
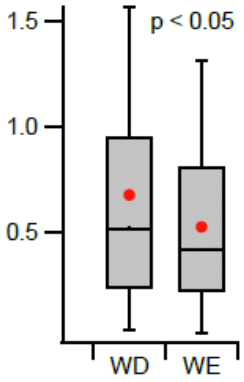
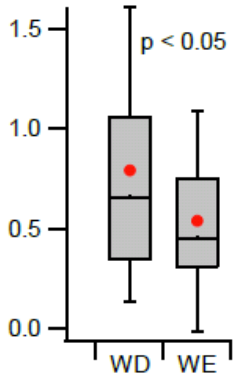


Steel mills

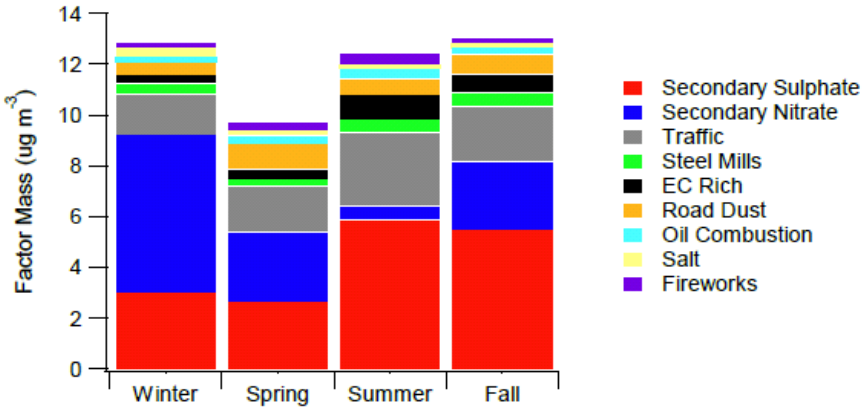


Elemental carbon rich



Road dust

Weekday-weekend patterns indicate local anthropogenic influences



Seasonal patterns more related to meteorology (mixing & chemical processing)

Temporal patterns of 24h data better for identifying regional sources

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Aerosol Mass Spectrometer:
Windsor 19 days Jan 2005

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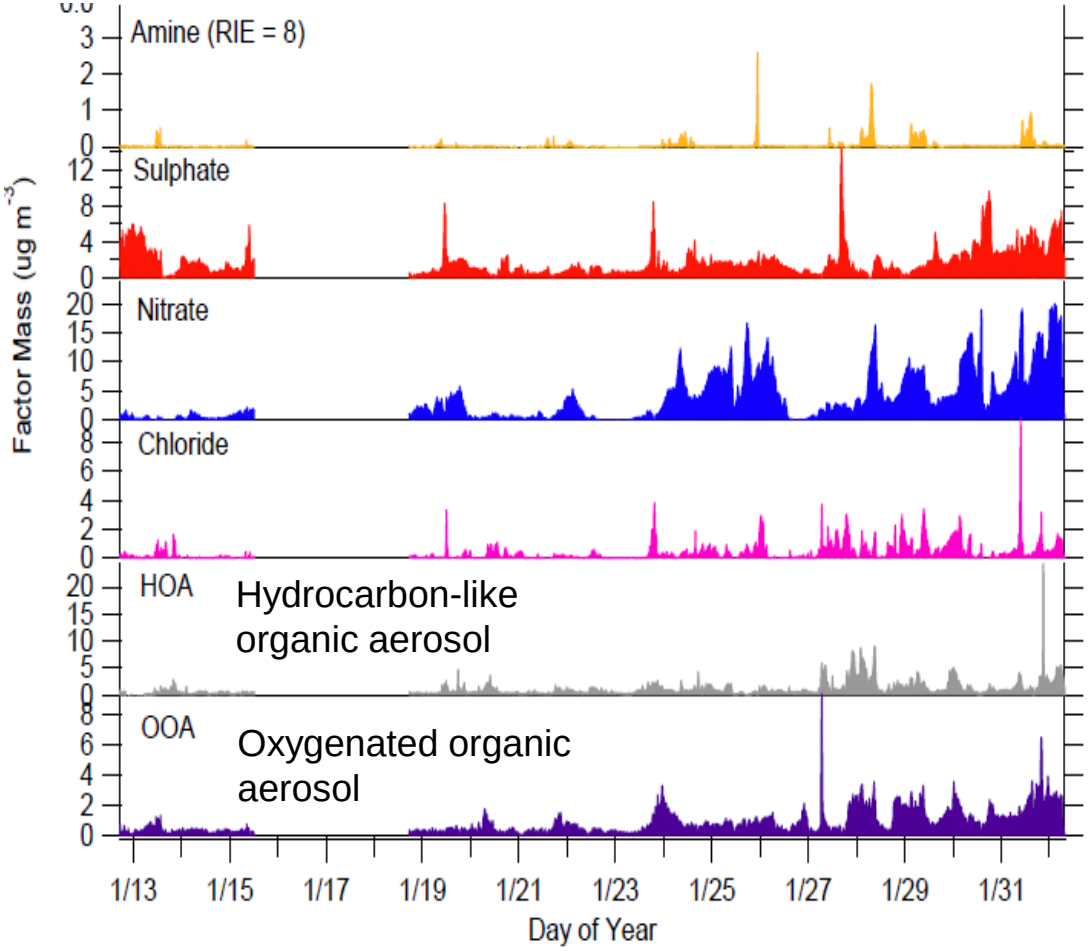

5-min time resolution of AMS reveals sharp peaks of local sources (e.g. amine, local sulphate)

Non-refractory composition is better for identifying "secondary" contributions

Particle size information can help resolve contributions

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AMS data: Sulphate factor

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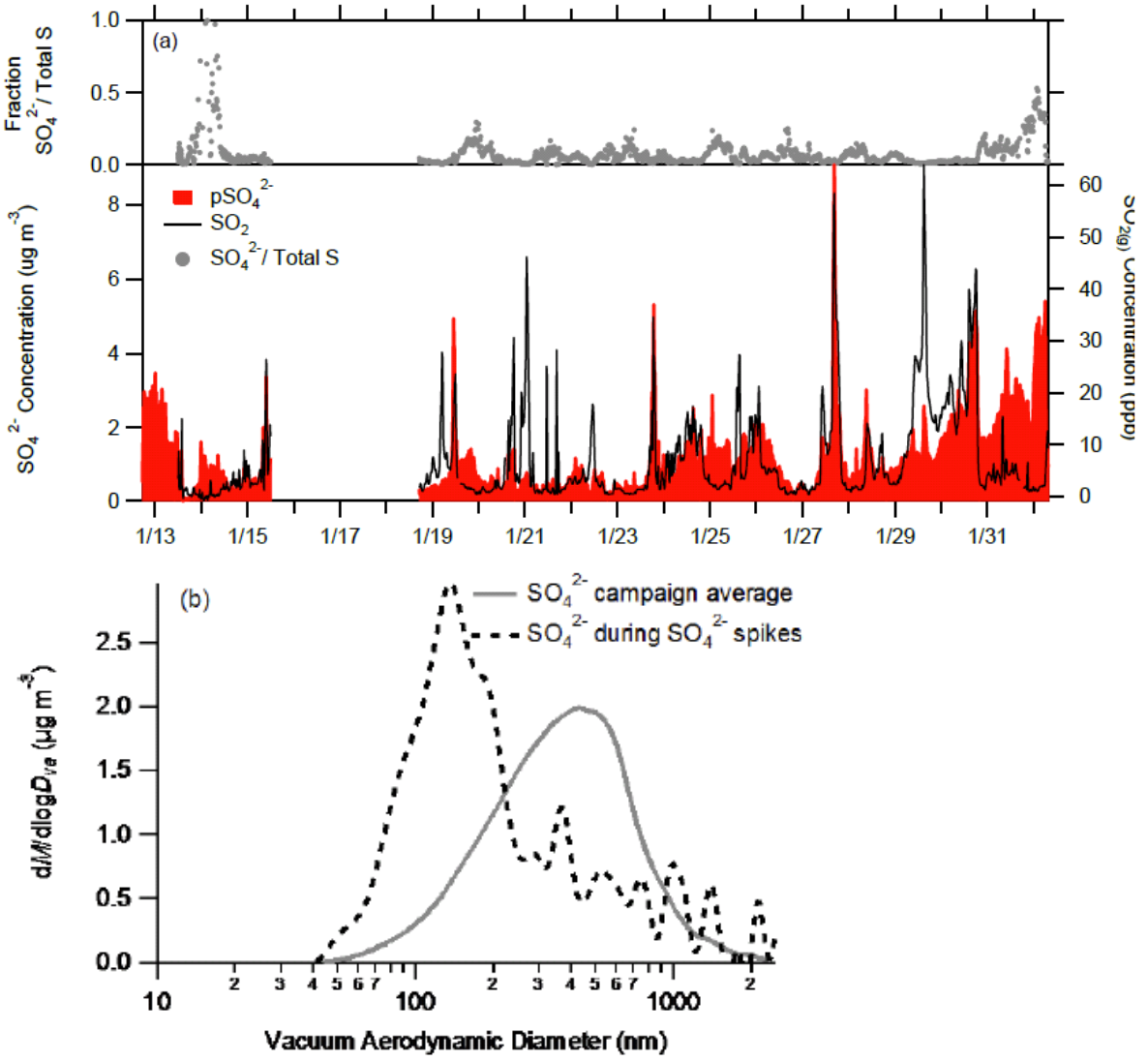

Local source indicated by brief “spikes of sulphate during periods of high SO_2 and low extent of oxidation (sulphate/total sulphur)

Particle size smaller during these spikes and particles are more acidic

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Single Particle (ATOFMS) Data:
Windsor 21days June -July 2007

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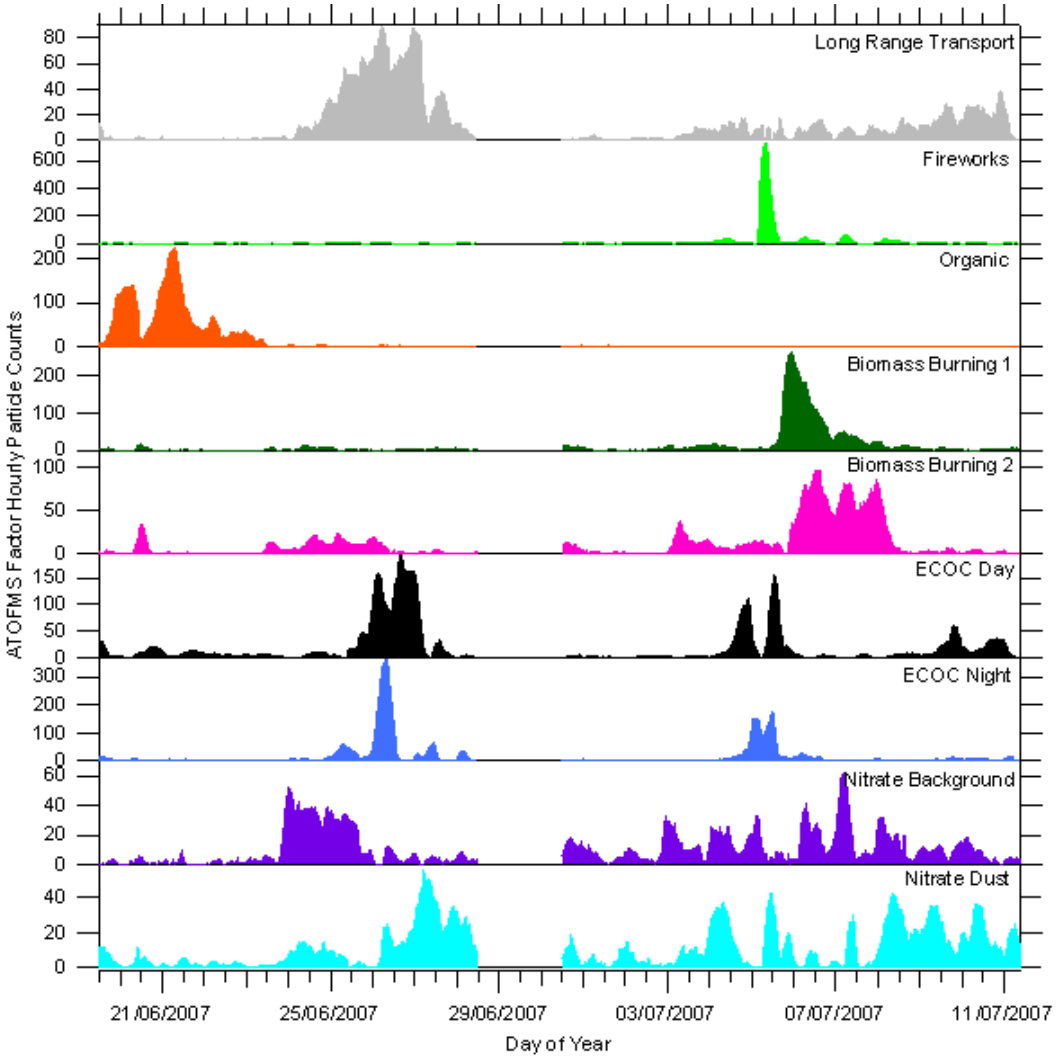

Higher resolution with single particle data allows:

- More detailed resolution (e.g. nitrate sources)
- Better separation of sources, transport and local processing (e.g. ECOC day/night)

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Single Particle (ATOFMS) Data:
Toronto Mar 2007 -Jan 2008

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Combine high time resolution with long term sampling allows analysis at multiple temporal scales

Main Family	Number of Particle-Types	Percent Contribution
DUST	3	**8.7 %**
SALT	1	**2.3 %**
INORGANIC	2	**1.3 %**
BIOMASS BURNING[1]	5	**14.5 %**
POTASSIUM RICH	2	**5.0 %**
ELEMENTAL CARBON[1]	4	**7.3 %**
ORGANIC CARBON[1]	3	**38.4 %**
AMINES[2]	**1**	**22.5 %**

Street Dust Particles (#/cm^3)

ATOFMS Toronto Mar 2007 -Jan 2008

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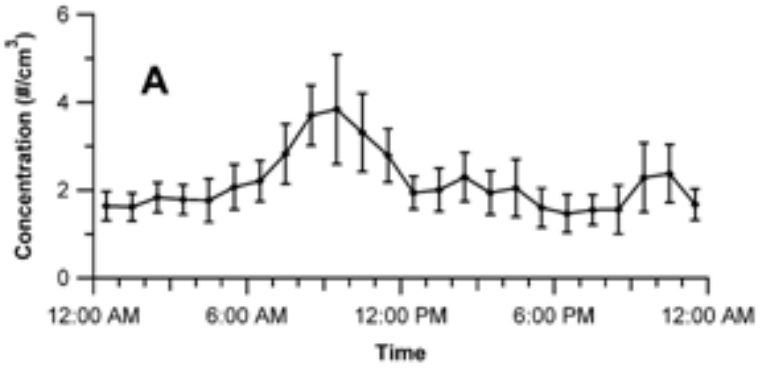
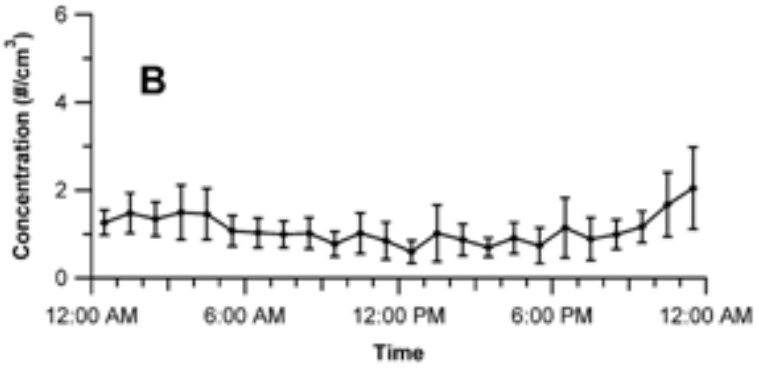
Weekdays

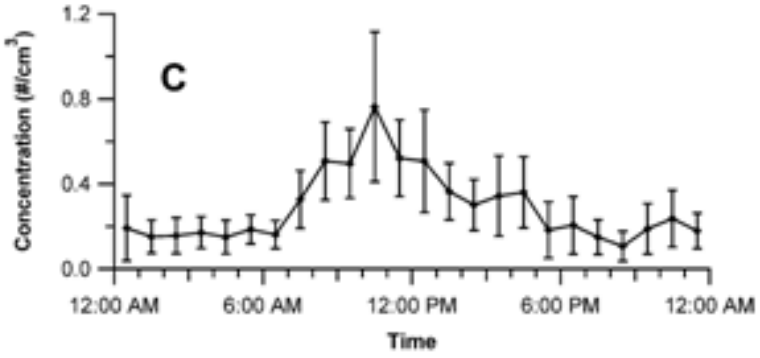
Weekends

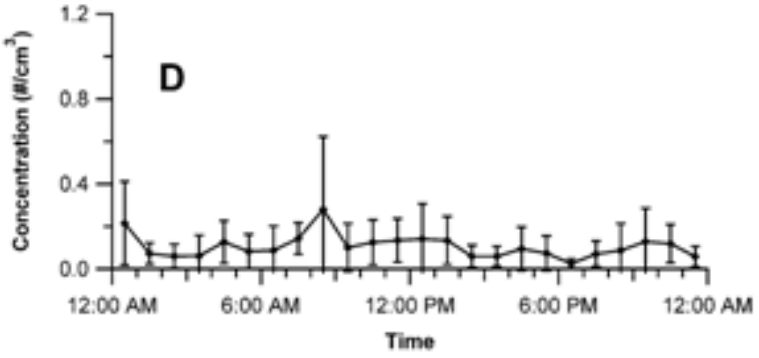
Wear from vehicles (83%)





Entrained Soil (17%)





- Temporal patterns show anthropogenic influence
- Composition shows different sources

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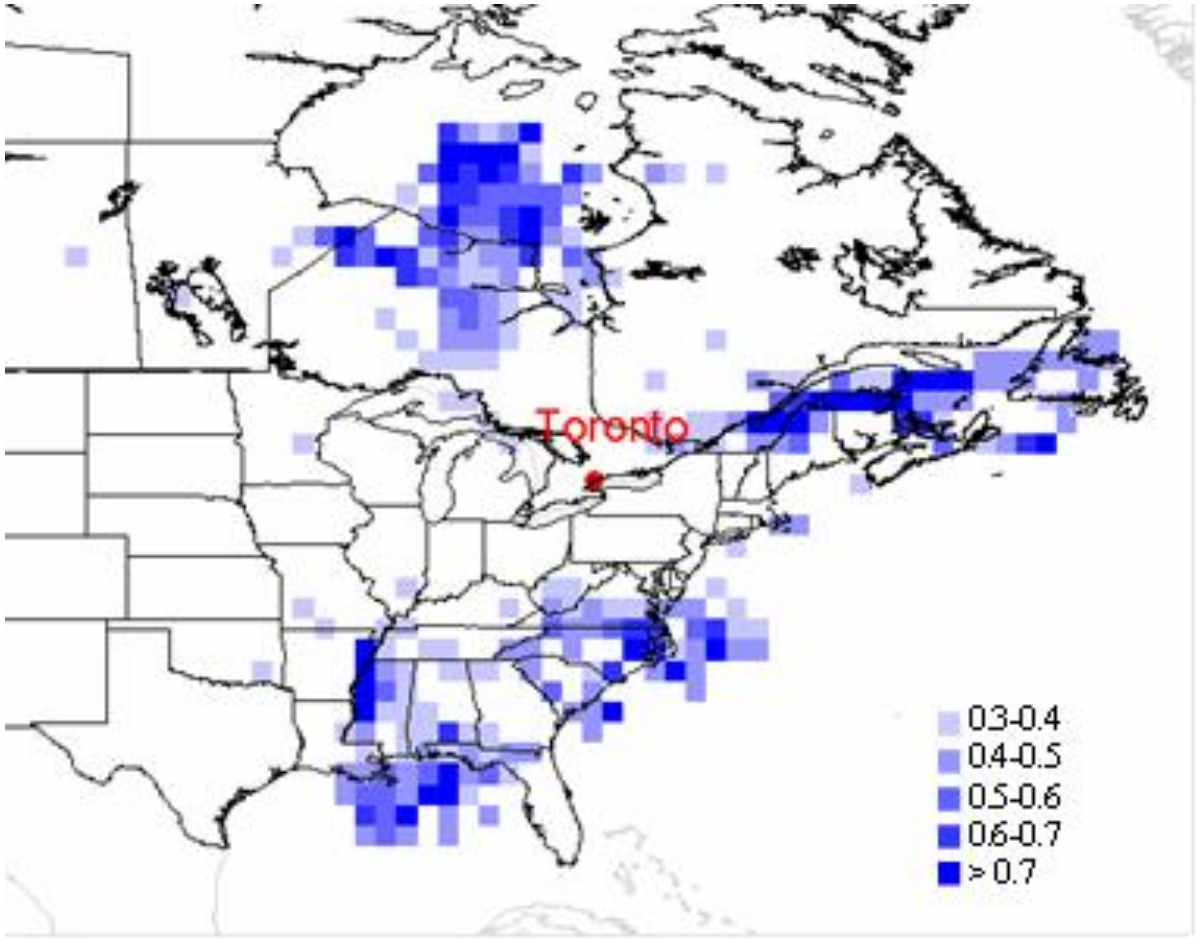
Salt Particles:
Toronto Mar 2007 -Jan 2008



PSCF plots for particle types identify “potential” geographic origins

Salt Particles

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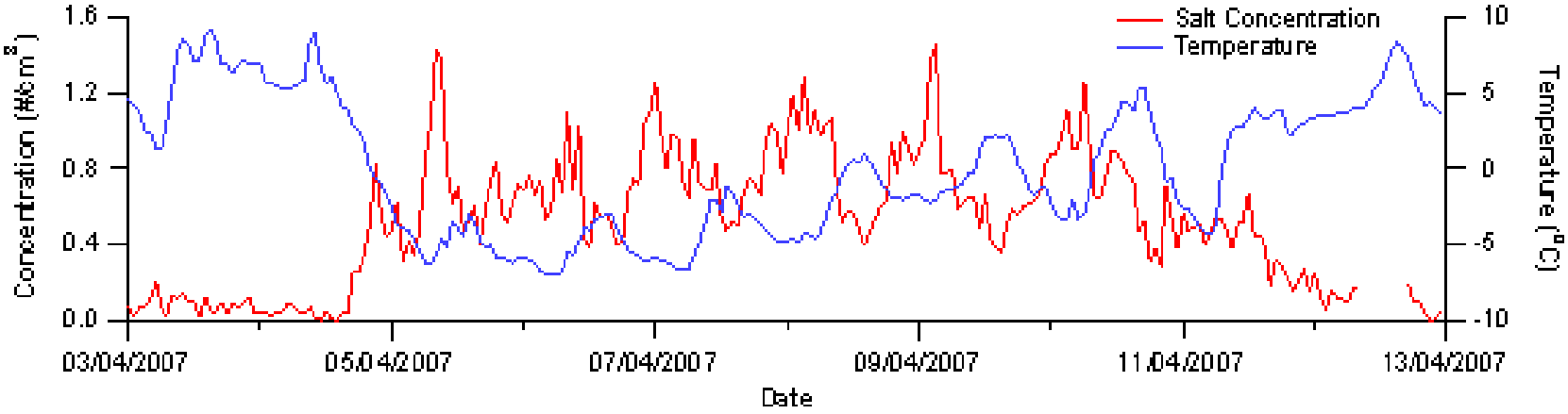

April 3-13 2007

PSCF suggests Hudson's Bay yet day/night oscillation suggest a local source

Physical Characteristics:
Ultrafine particles

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- Scanning Mobility Particle Sizer *(size distributions for particles 3-1000 nm)*

- Fast Mobility Particle Sizer *(size distributions for particles 5.6-560 nm)*

- *Condensation Particle Counter (number concentrations for particles > 10 nm)*

- P-Track *(number concentrations for particles > 25 nm)*

Population Exposure Assessment
Traffic Related Pollutants

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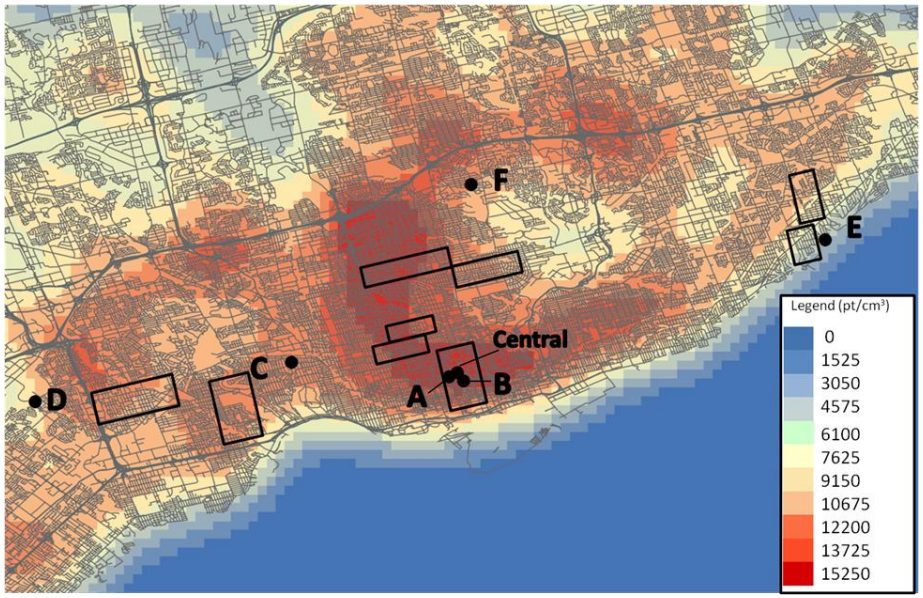
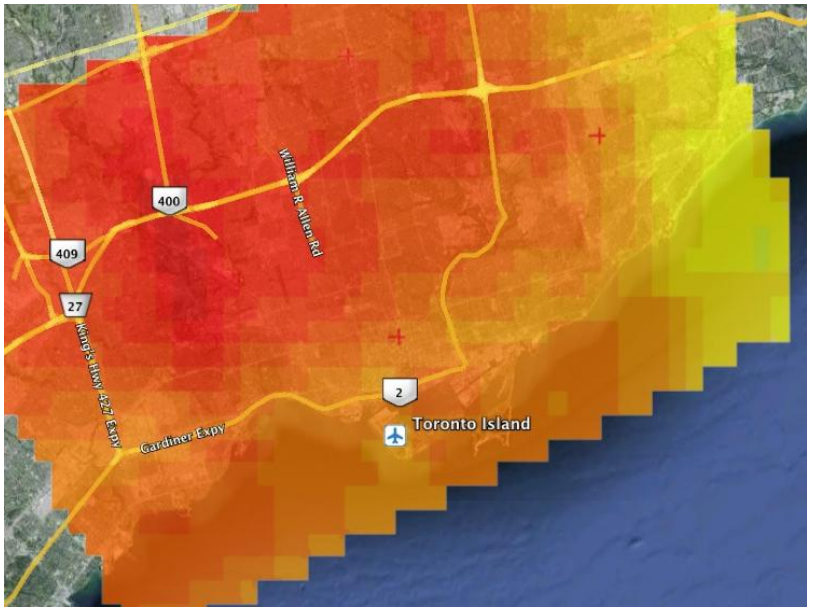


Ultrafine Particle Concentrations



NO_2 Concentrations

Population exposure was estimated using: fixed sites, mobile measurement, satellite remote sensing and modeling

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Long Term Temporal Patterns

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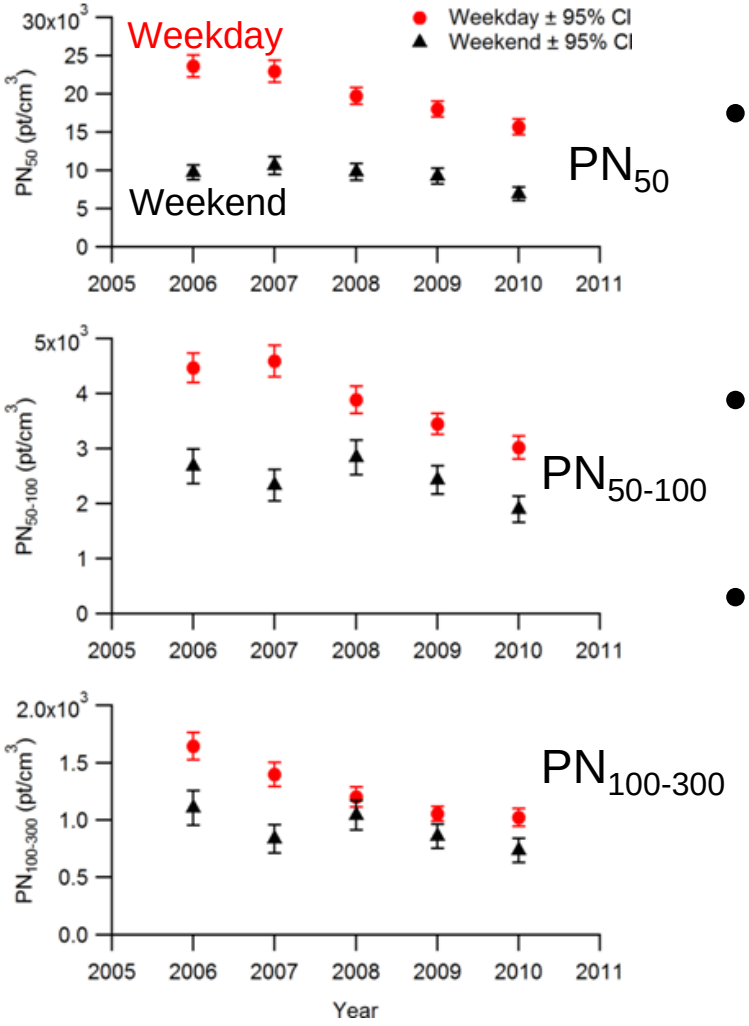

- Continuous reduction in number concentrations over five years
- Reduction largest for smallest particles
- Weekday/weekend differences decrease with size and time

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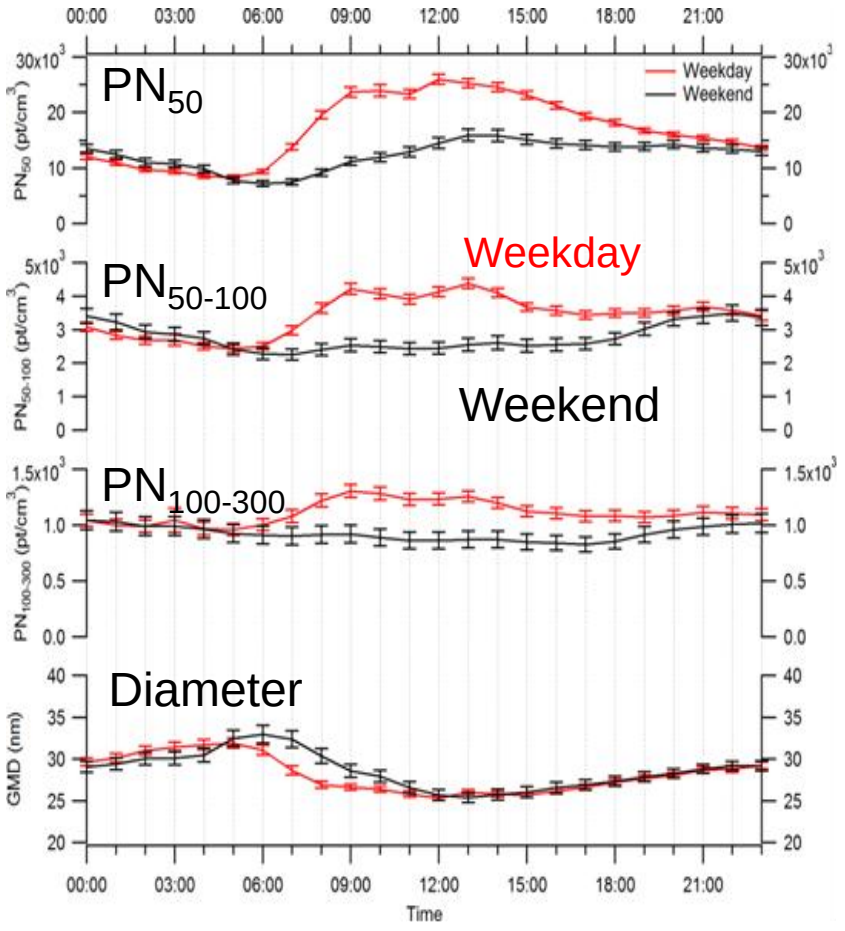
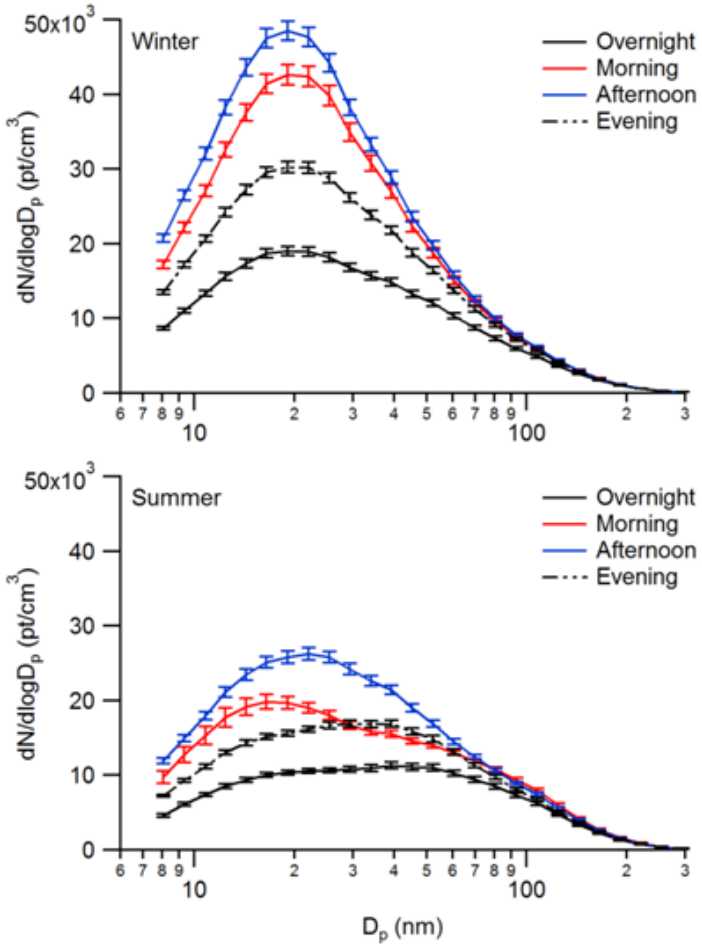
Diurnal Temporal Patterns



- Diurnal pattern is strongest for smallest particles
- Weekday/weekend differences decreases with particle size
- Geometric mean diameter smaller on weekdays

Seasonal Temporal Patterns



- Concentrations are higher in winter
- Modal diameter ~20 nm in winter
- Particle growth to mode ~40 nm overnight in summer

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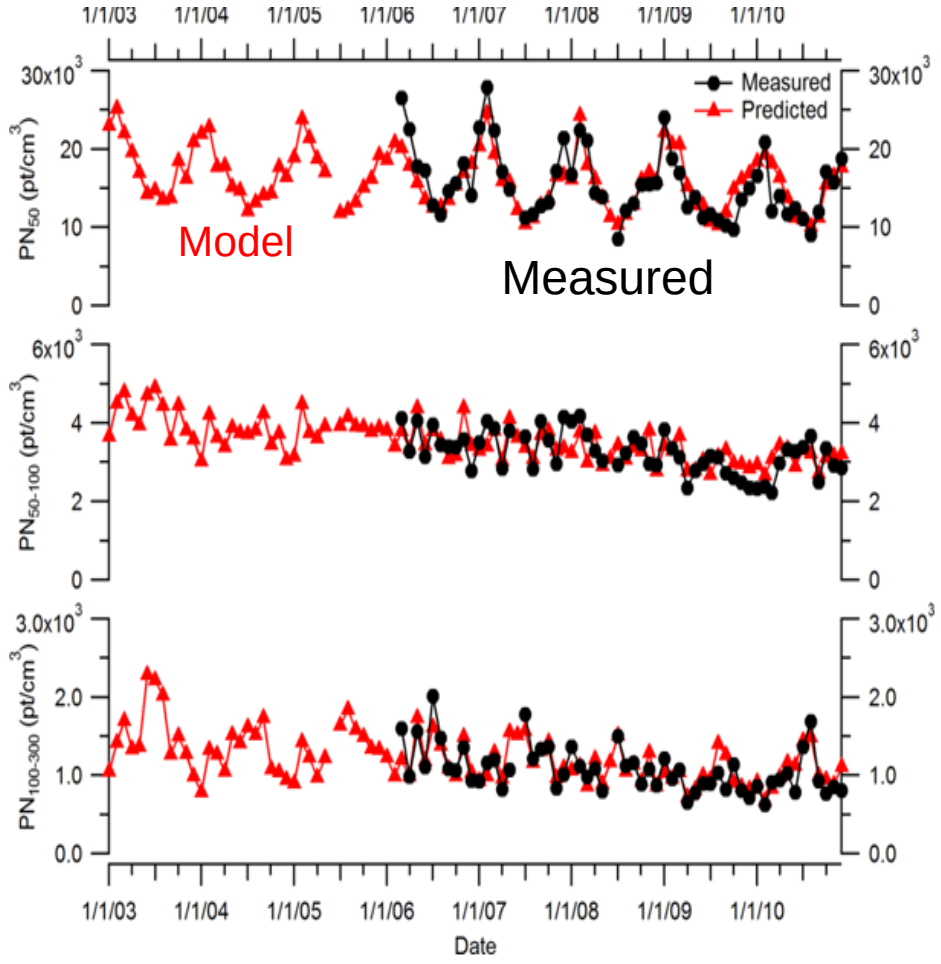
Modeling Temporal Patterns



- Multiple linear regression model developed to estimate PN concentrations (NO_2, $PM_{2.5}$ WS, T)
- Model was evaluated using excluded data
- Model indicates continuous reduction since 2003

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Spatial Pattern in Toronto

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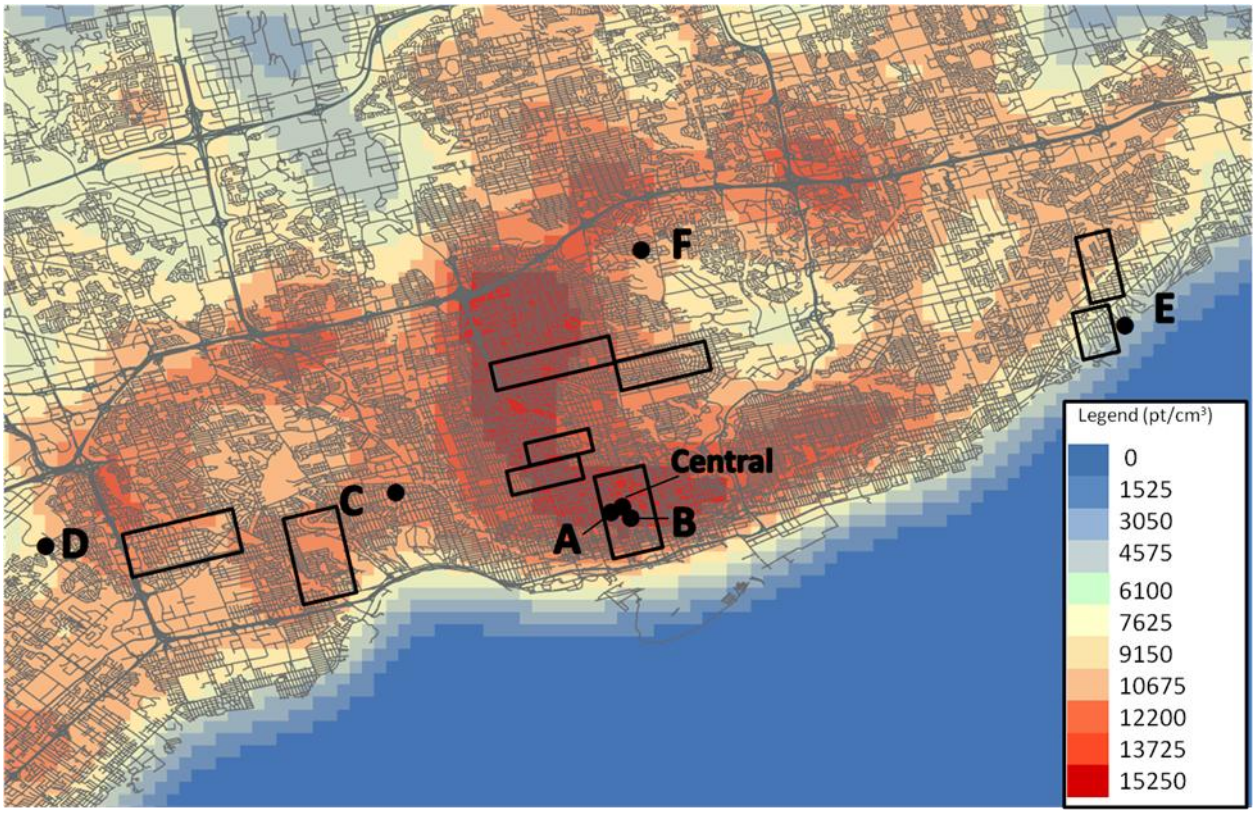

Summary

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- New high time resolution instruments allow detection of temporal patterns at multiple time scales
- Interpretation at multiple times scales offers substantial benefits for receptor modeling and exposure assessment
- Time resolution, chemical breadth and degree of quantification need to be balanced based on research or monitoring focus of interest.