

Update on Canadian PM_{2.5} Monitoring Network

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Presentation Outline

- Background on NAPS
- Evolution of PM_{2.5} mass measurement
- Inter-comparability of continuous PM_{2.5} instruments
- Evolution of PM speciation measurement program

What is NAPS?

- National Air Pollution Surveillance (NAPS) Network
- the NAPS program is a cooperative federal-provincial-territorial network of over 800 ambient air quality monitoring instruments across Canada, mostly in urban centres
- network began in 1969
- a formal agreement (MOU) has been developed for the NAPS program – signed in fall 2004
- this agreement formalizes the roles and responsibilities of the NAPS program participants, and documents the successful and collaborative operating arrangements that have evolved over the three decades.

Environment Canada Role in NAPS

- Provision of instruments to partners - specifications set for whole network
- Quality assurance - audits and inter-lab studies
- National data base and national data reports - moving to web-based reporting
- Data interpretation and scientific advice
- Chemical analyses - PM, metals, anions and cations, carbon, VOCs, PAHs, PCCD/F
- Training for new equipment, software

Federal Investments in NAPS PM Program (2001 – 2005)

<i>Item</i>	<i>Total New or Replacement Units</i>
Continuous PM _{2.5}	123
Continuous PM Upgrades	95
Filter Based PM _{2.5}	37

Total Expenditure of \$2.5M per Year Capital for PM, Ozone and other field instruments - substantial additional investment in laboratory equipment and O&M.

Canada-wide Standard (CWS) for PM_{2.5}

- a CWS of 30 µg/m³, 24-hour averaging time by year 2010. Achievement to be based on the 98th percentile ambient measurement annually, averaged over 3 consecutive years.
- no annual standard
- daily sampling required
- no prescribed measurement method
- no prescribed temp. & pressure for concentration units
- reference to a Monitoring Protocol document

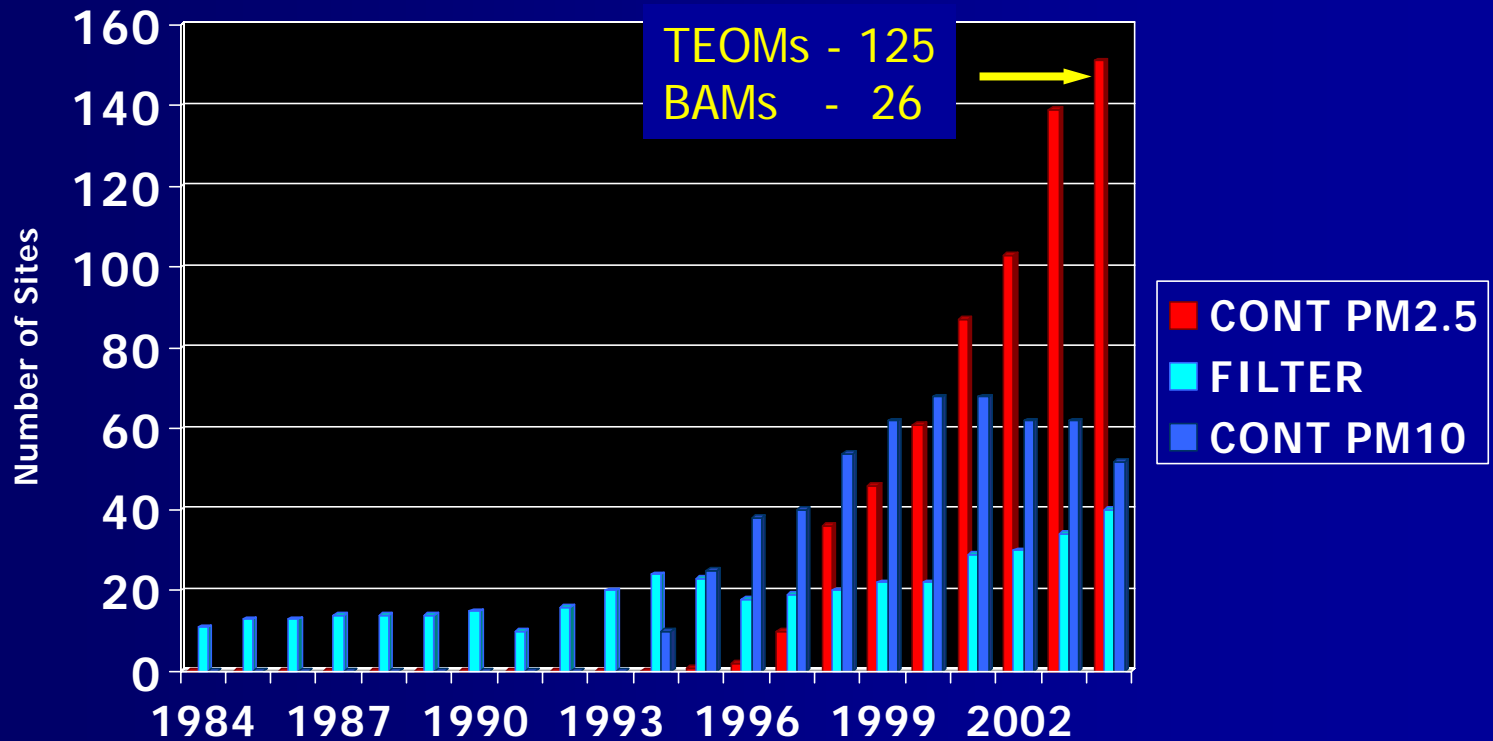
Evolution of PM_{2.5} Mass Monitoring in NAPS

- dichotomous sampler program began in 1984 – PM_{2.5} and coarse mass
- CWS drove need for additional PM_{2.5} measurement sites
- many provincial networks had adopted continuous methods for PM₁₀ measurement and had invested heavily in the technology

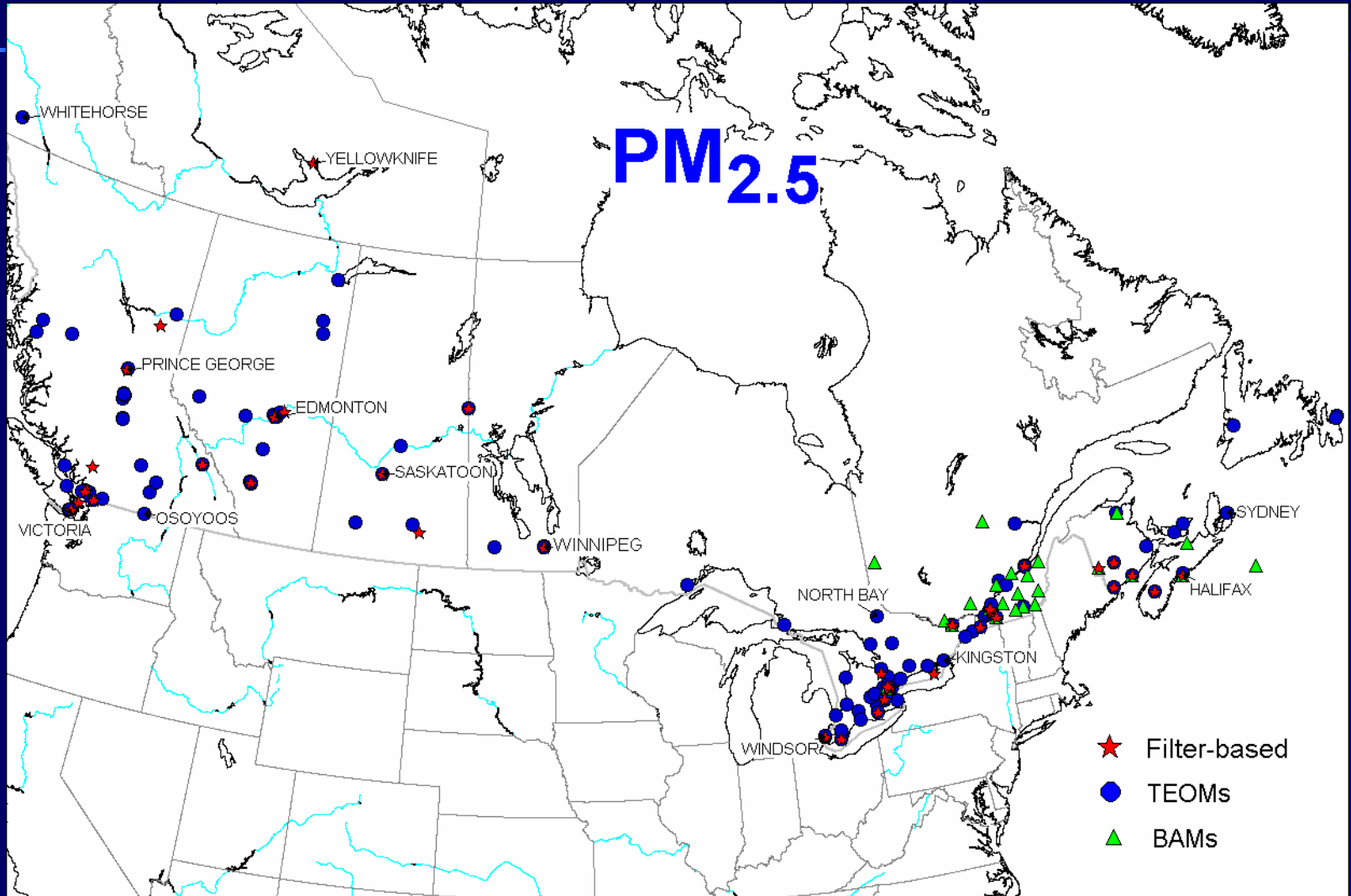
Clear advantages to continuous mass measurement

- reduced manpower and hence ability to operate greater numbers of sites (esp. for daily measurements)
- integration with existing data management methods
- near real-time data for use in air quality index (AQI) and AIRNOW reporting
- diurnal time series of PM mass
- reduction in potential sources of error (fixed bias vs. random error)
- greatly improved data completeness

Practicality of continuous instruments led to rapid growth in PM_{2.5} network



Existing PM_{2.5} Monitoring Sites in Canada (2004)



Results of Recent Inter-comparison Studies of Continuous Analyzers at Canadian Sites

- Network Instruments:
 - TEOMs operating at 40°C (TEOM)
 - TEOMs with Sample Equilibration System (operating at 30 °C) (TEOM-SES)
 - TEOMs with FDMS (TEOM-FDMS)
 - BAMs with smart heaters (BAM-SH)
 - FRM PM_{2.5} instruments (FRM)
 - sequential Partisol PM_{2.5} instruments (Partisol)
 - sequential and manual dichotomous samplers (Dichot)

Inter-comparability of PM_{2.5} Mass Measurement Instruments

- true measurement of ambient aerosol is rarely, if ever, done as the act of sampling or measuring usually does not capture the vapor-phase and also disrupts the equilibrium
- different PM_{2.5} sampling methods may provide different estimates of PM mass

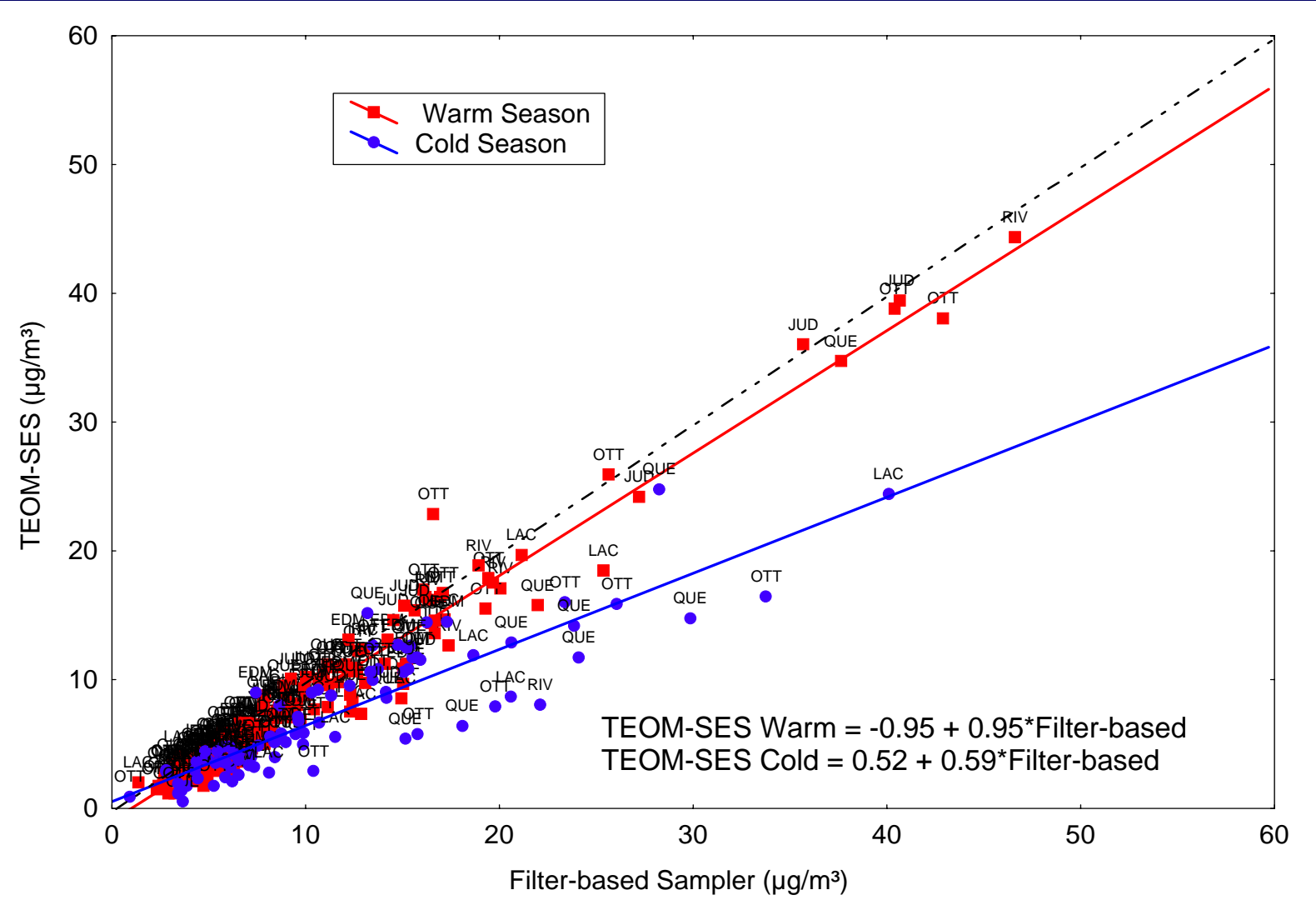
Issues Influencing PM_{2.5} Mass Measurements and Inter-comparability of Instruments

- majority of continuous instruments in Canada are TEOMs operating at 40°C or at 30°C with dryers
- sampling with heated sample inlets such as that employed by the TEOM causes a loss of semi-volatiles
 - semi-volatiles lost include ammonium nitrate and some portion of organic carbon
 - largest differences expected in cold months in areas with high nitrate loadings

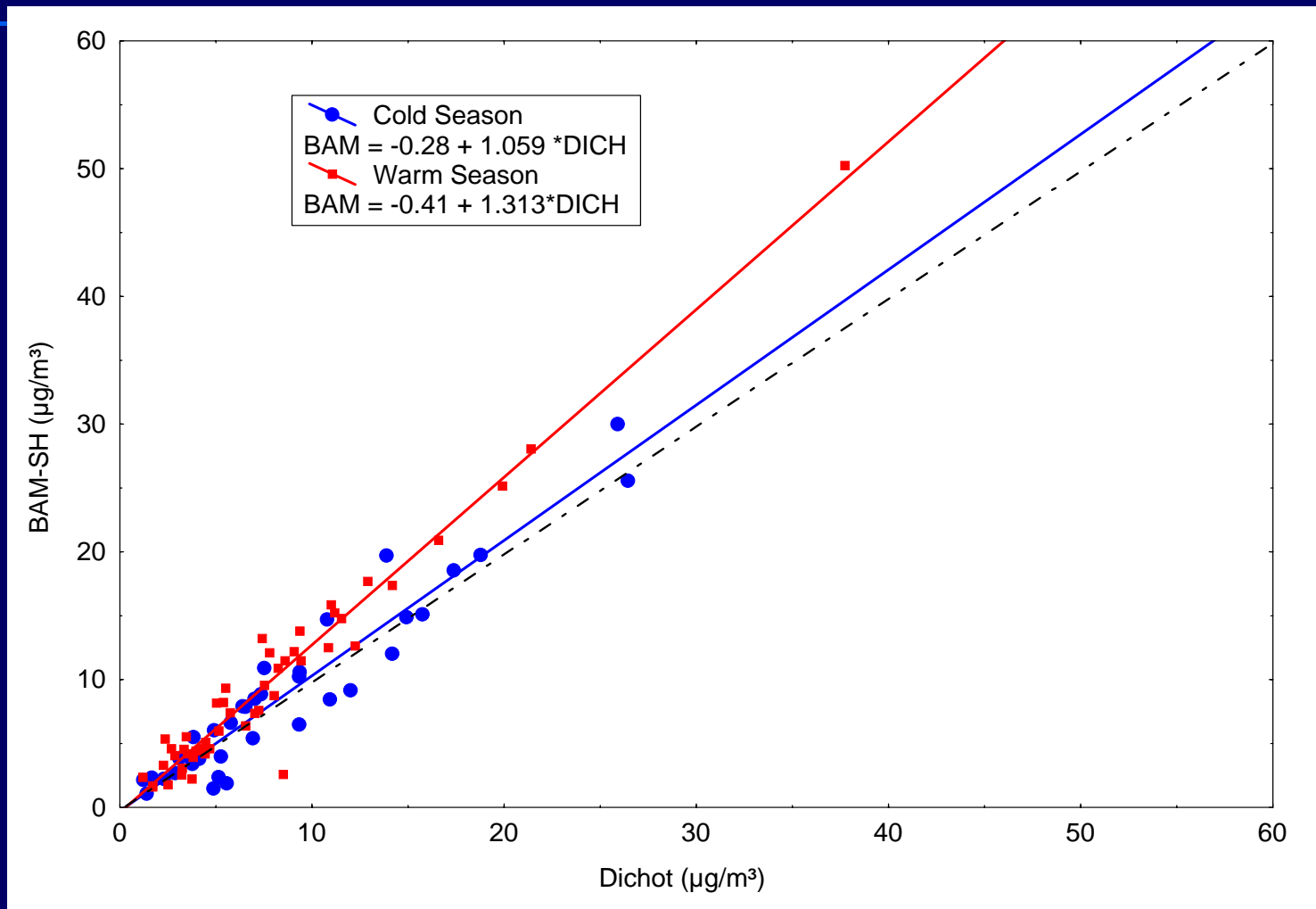
Observations from field inter-comparisons of continuous and manual methods

- at most urban sites the TEOM instrument is biased low vs. filter-based measurements during the cold season with mean annual differences of 1.5 to 3 $\mu\text{g}/\text{m}^3$ and 98th percentile differences of 4 to 15 $\mu\text{g}/\text{m}^3$.
- although less data are available, the BAM-SH shows less variation between warm and cold season linear regression results but consistently reads higher than filter-based methods
- based on very-limited data the TEOM-FDMS appears to perform similarly to the BAM-SH

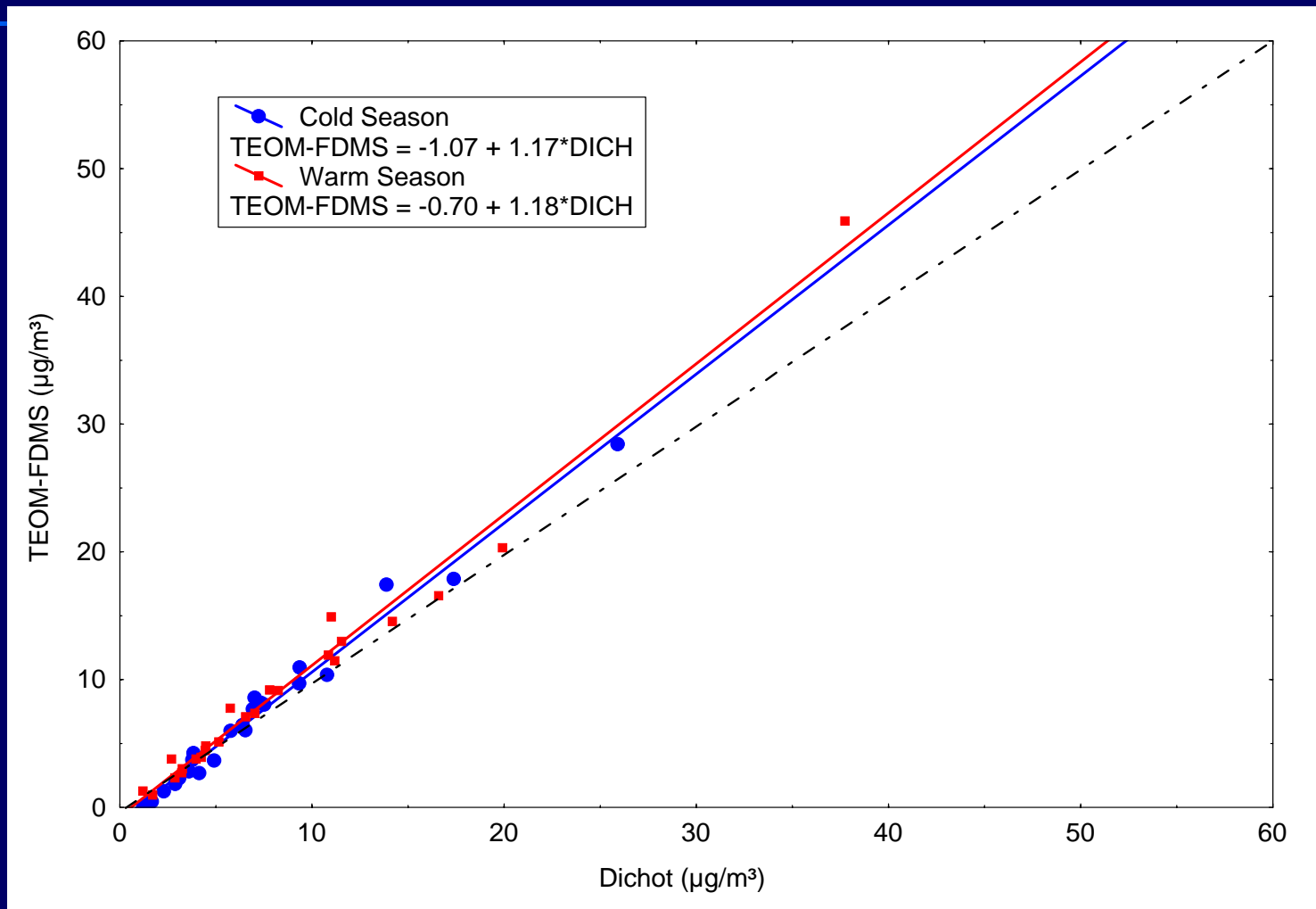
Linear regression results for 24h data – TEOM-SES all sites combined (2003-2004)



Linear regression results for 24h data BAM-SH Ottawa (2004)



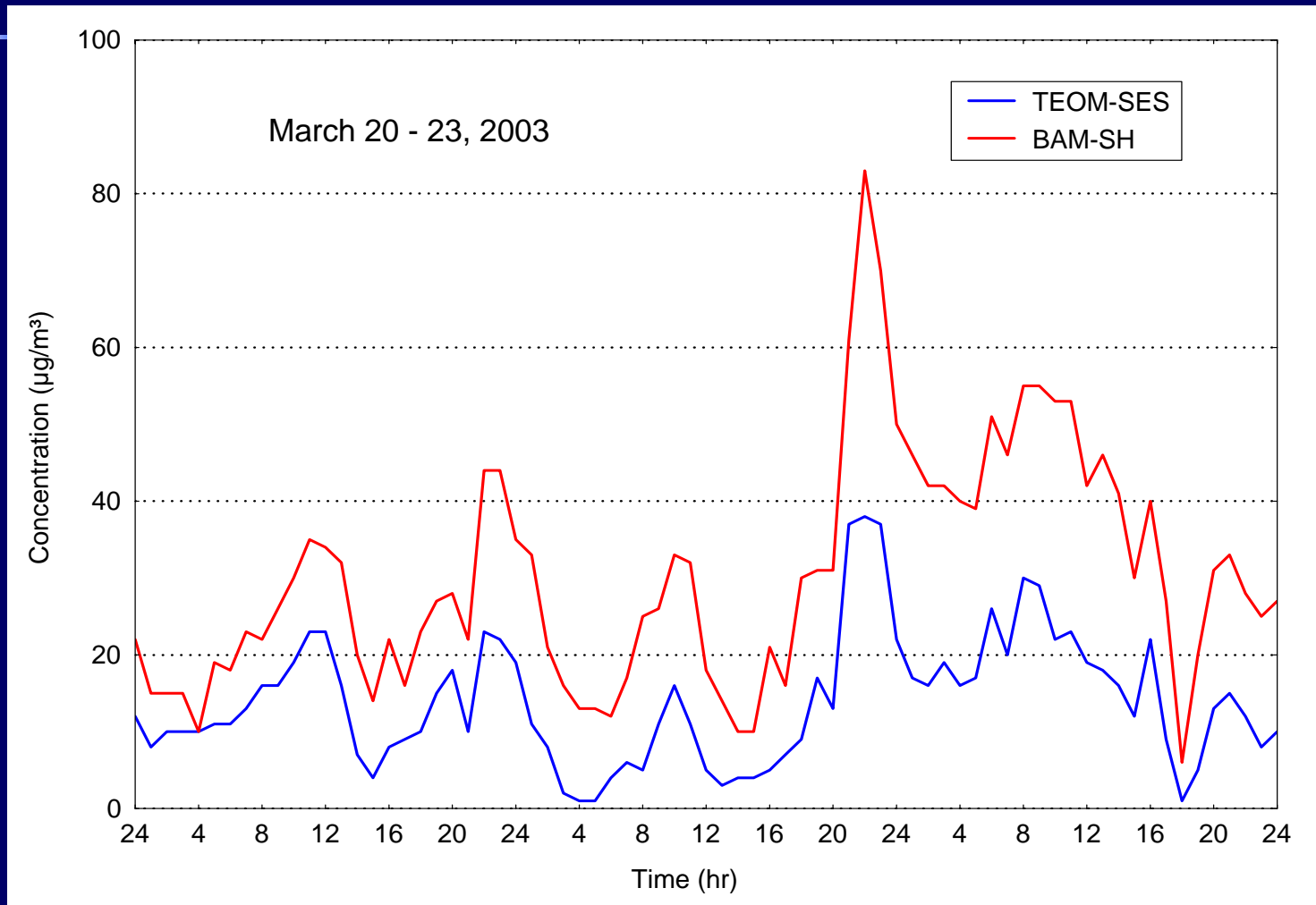
Linear regression results for 24h data TEOM-FDMS Ottawa (2004)



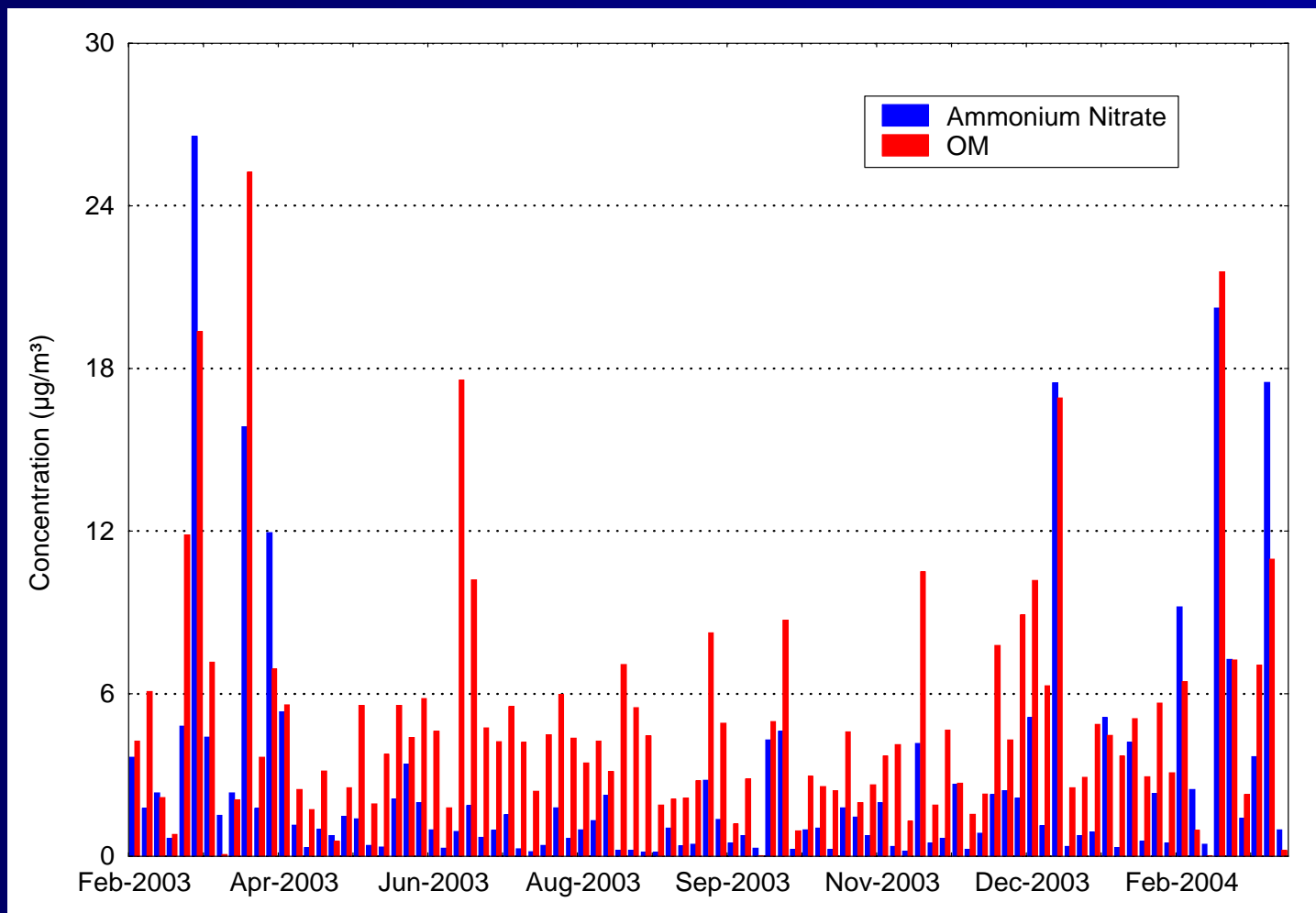
Observations from field inter-comparisons of continuous and manual methods

- very large differences in hourly concentrations are experienced between collocated BAM-SH and TEOM-SES instruments in the cold season - this has obvious implications for AQI/AIRNOW reporting from networks with mixed instruments
- no data correction scheme can solve this problem

Comparison of TEOM and BAM-SH Results During a Cold Season PM_{2.5} Episode – Montreal, Riviere des Prairies



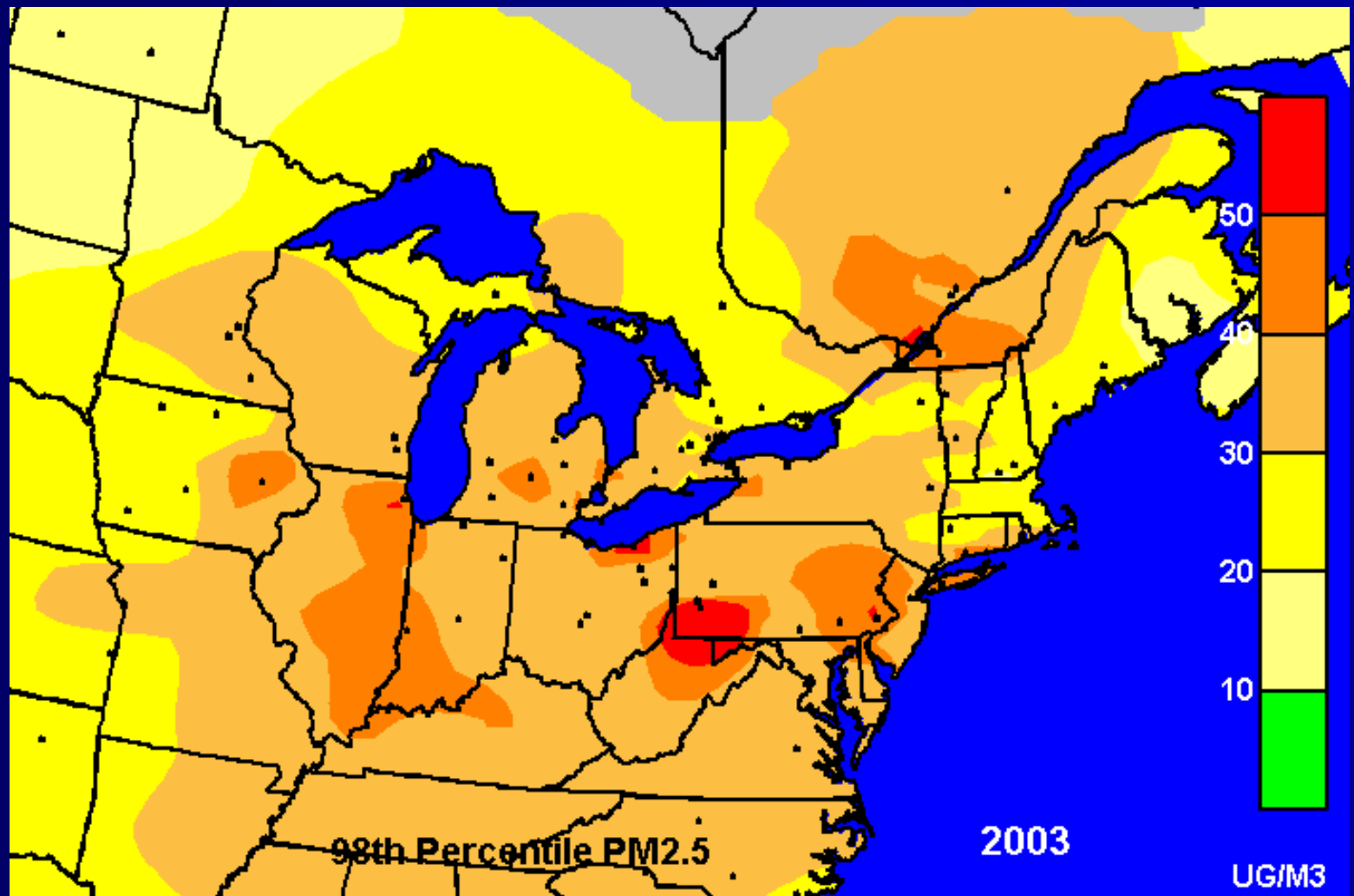
Daily Time Series of Ammonium Nitrate and OC at a downtown Montreal Site



Recommendations and actions:

- a reference method for PM_{2.5} mass is required - all filter-based and continuous mass measurements should be referenced to this
- standard operating procedures (SOPs) are required for continuous monitors deployed in the NAPS network
- a NAPS Manager's committee has developed a draft Canadian PM_{2.5} reference method and draft SOPs for current field instruments
- would need to be incorporated into CWS probably through the Monitoring Protocol document
- data quality objectives need to be developed to determine acceptable comparability between instruments on a 24-hr basis
- more extensive national inter-comparisons of continuous and filter –based methods are required

Discontinuities at the border in continuous PM_{2.5} measurements?



Evolution of PM Speciation Monitoring in Canada



Sequential dichotomous
Partisol (R&P) for
 $PM_{2.5}$ and PM_{coarse}



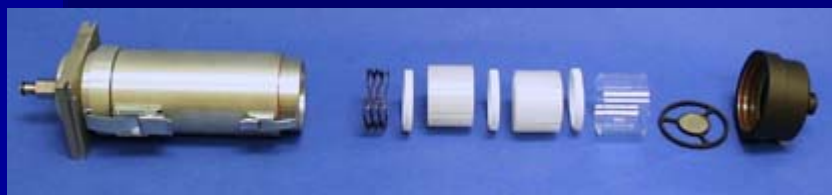
Sequential R&P
Chemcomb
cartridge-based
sampler for $PM_{2.5}$
speciation

Objectives

- Build on existing dichotomous sampler network
- Quantify all major components of PM including ammonium nitrate, black carbon and organic carbon
- Quantify important gas phase species including ammonia and nitric acid
- Quantify important tracers for specific PM sources
- Long term, high-quality observations
- Data for regional and source-receptor modelling

Nine components for Each Integrated Speciation Sample Period (24h)

<i>Unit</i>	<i>Module Description</i>	<i>Media</i>	<i>Function/Analytes</i>
<i>Dichot Partisol</i>	Fine Fraction Filter	47 mm Teflon	Mass, Metals - XRF Acid Digest ICPMS
	Coarse Fraction Filter	47 mm Teflon	Mass, Metals - XRF
<i>Speciation Sampler</i>	Module C (4 components)	Sodium Carbonate Denuder	Collection/Removal SO ₂ & HNO ₃
		Citric Acid Denuder	Collection/Removal NH ₃
		Teflon Filter	Sulphate and other major Inorganic and Organic Ions
		Nylon Filter	Nitrate, Sulphate
	Module A	Pre-fired Quartz Filter	Black carbon, Organic carbon - IMPROVE
	Module B (2 components)	Teflon Filter	Mass Water Extract ICPMS
Pre-fired Quartz Filter		Organic carbon artifact	

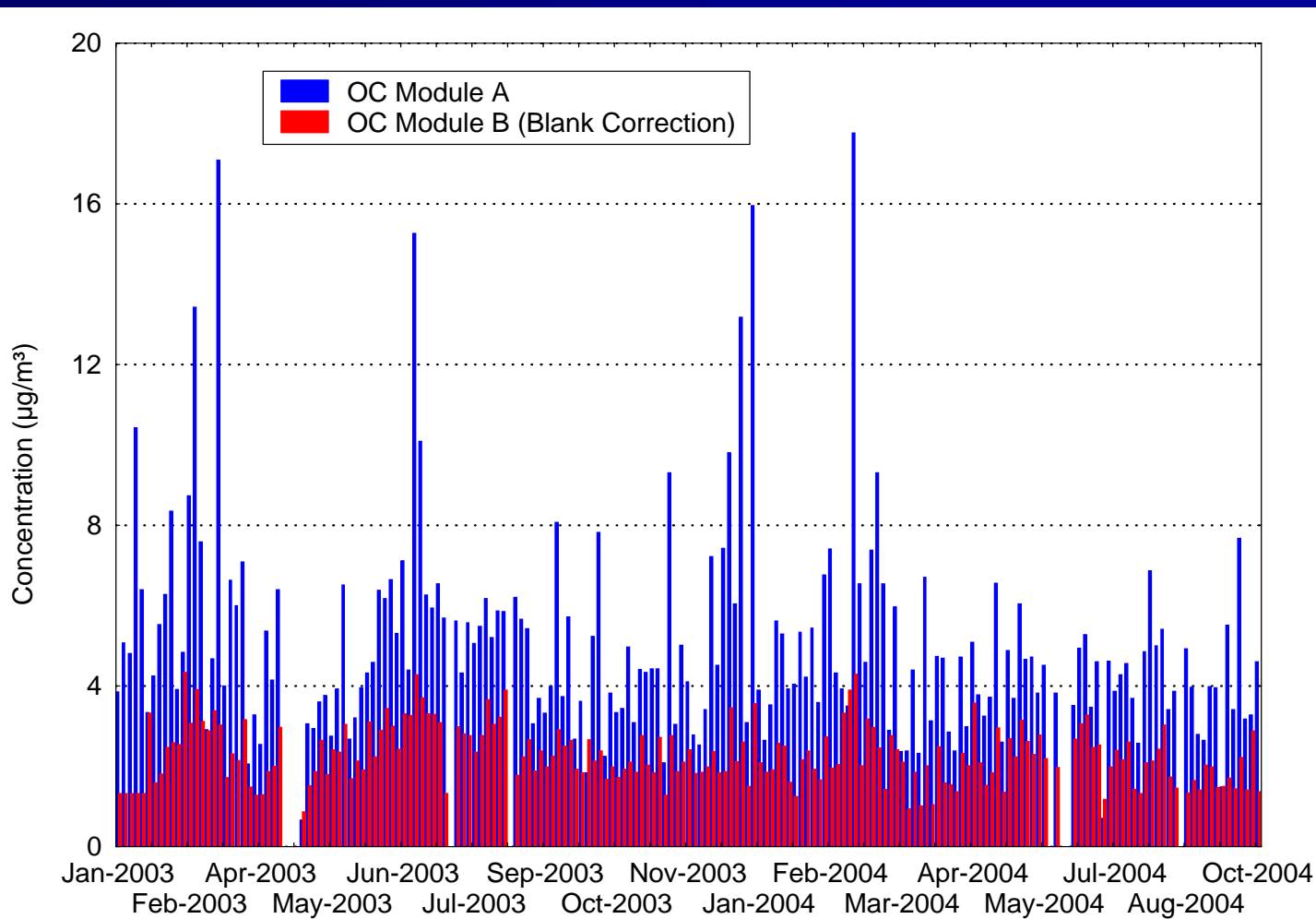


Chemcomb cartridge

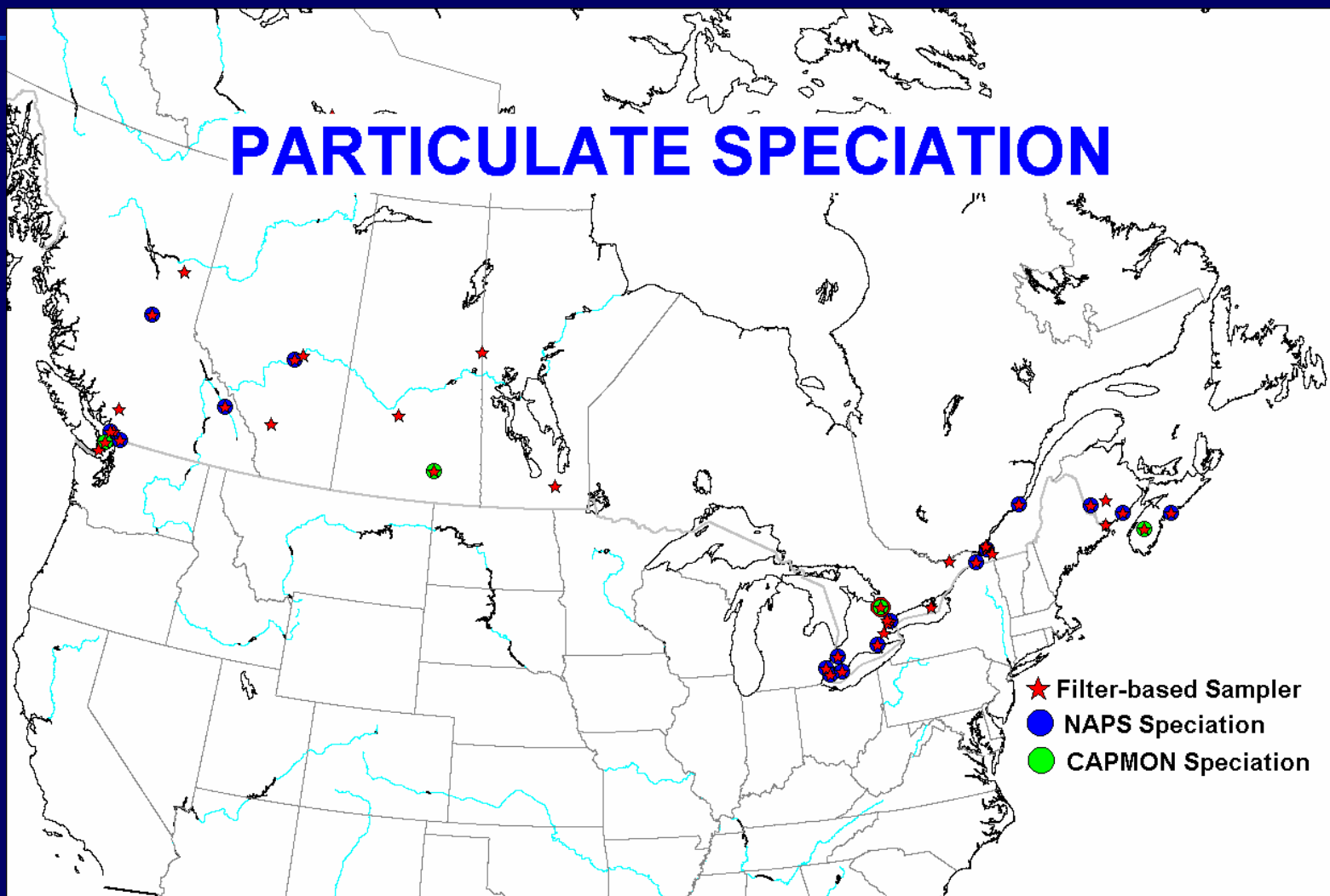
Analytical Descriptions

- EDXRF – Non- destructive - 50 elements
DL 1-5 ng/m³
- IC – Water extraction – 20 organic and inorganic ions DL ~ 0.01 µg/m³
- ICPMS – Agilent 7500c ICP-MS
Water extraction – 20 metals - DL 0.02 – 0.2 ng/m³
- TOR/TOT – DRI Model 2001 thermal/dual-optical carbon analyzer and IMPROVE analytical protocol
OC1 – OC4, EC1 – EC3, POC – transmittance and reflectance – DL 0.6 µg/m³ (OC) and 0.14 µg/m³ (EC)

Active Blank Correction for OC (Montreal 2003 – 2004)



Canadian Locations with Fine and Coarse Mass, Fine Mass Speciation



Other Speciation Program Outputs

- organic carbon and black carbon profiles and ratios
- high resolution metals and elements
- organic and inorganic ions
- free ammonia measurements and gas ratio
- coarse mass and elements

Summary

- rapid expansion in PM_{2.5} measurement sites but mostly continuous instruments and problems remain related to comparability of measurements
- speciation network will comprise 17 to 20 total sites with methodologies compatible with U.S. networks
- opportunities for co-location of measurements and sharing and integration of data
- border-less data presentation a goal

Thanks!