Performance of Continuous $PM_{2.5}$ Monitors at a Monitoring Site in Ottawa, Canada

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Environment Canada Environnement Canada

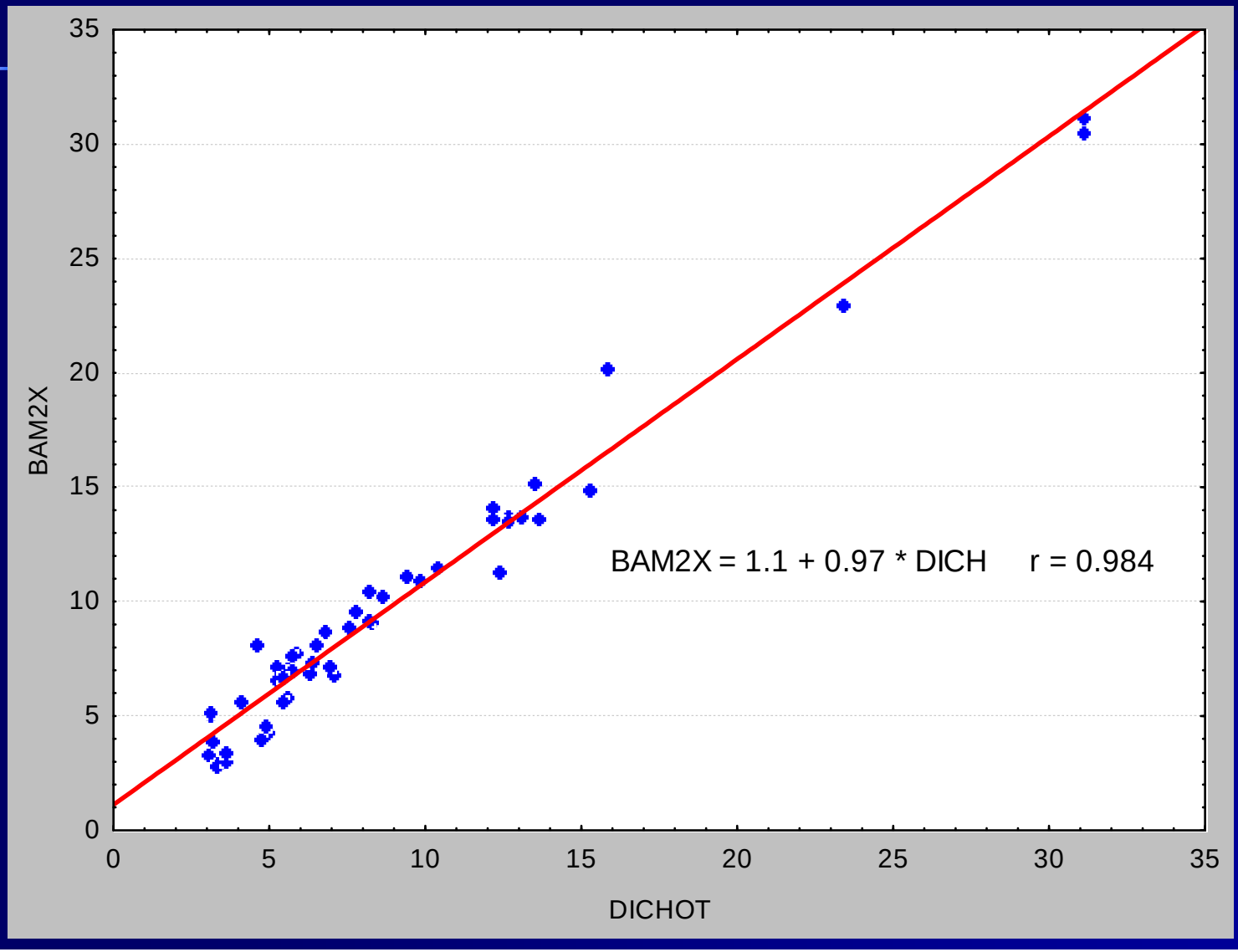
Ottawa Monitoring Site

Met-One BAM 1020	May 2004
Met-One BAM 1020 (new)	Nov 2006
Met-One BAM 1020(2x)	July 2007
TEOM SES (30°C)	May 2004
TEOM FDMS	July 2004
GRIMM 180 (PM_{10}, $PM_{2.5}$, $PM_{1.0}$)	Oct. 2005
Thermo SHARP 5030	June 2006

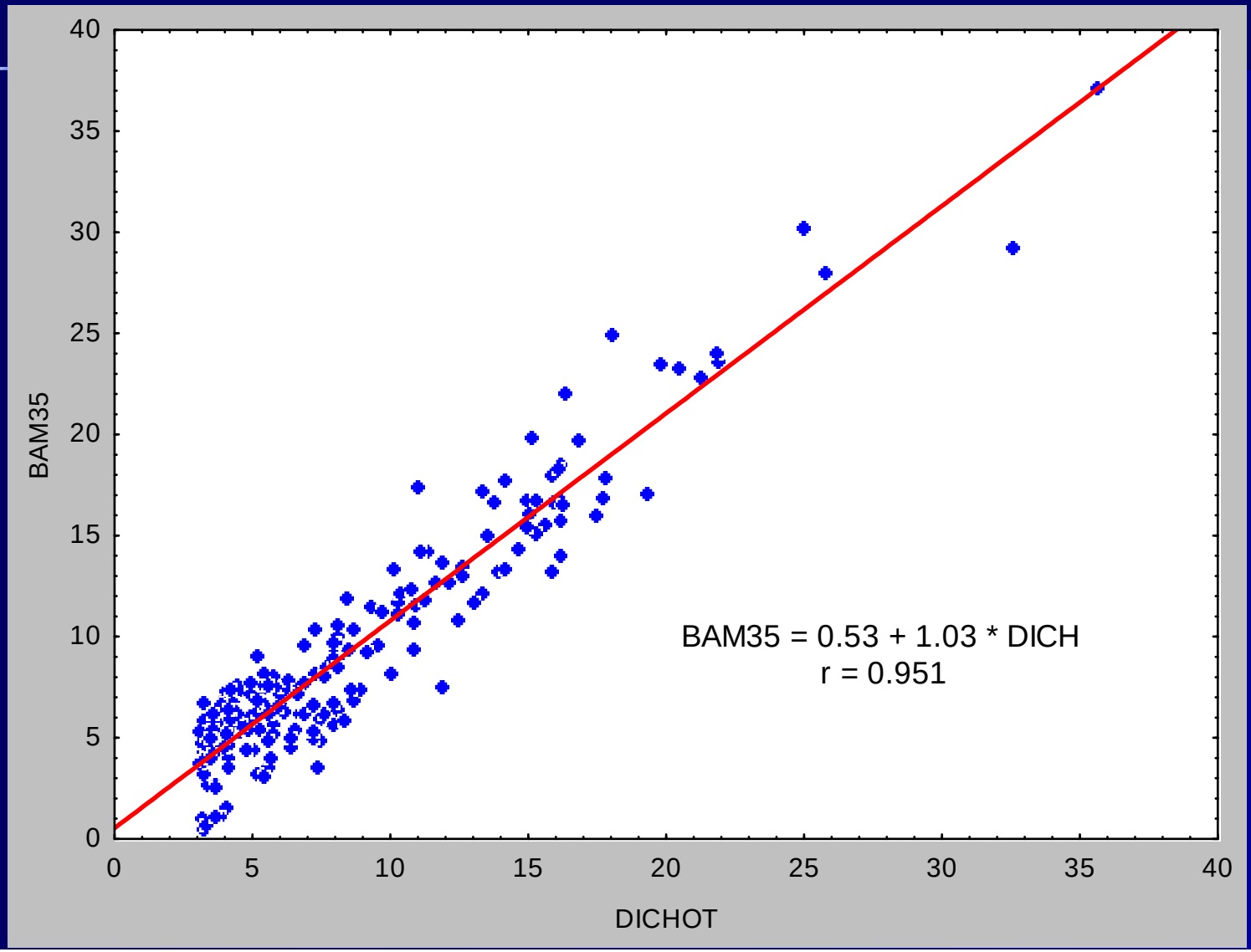
Met-One BAM 1020(2x)

- first continuous $PM_{2.5}$ instrument to receive EPA Class III Equivalency designation
- designation achieved with a 35% RH setting on smart heater
- improved detection level and precision due to redesigned tape transport system
- close geometry beta source configuration
- count time 8 minutes and sample time 42 minutes
- firmware revision 3.2.4
- VSCC (not in Ottawa)
- outside pressure sensor and reporting at actual conditions (not in Ottawa)

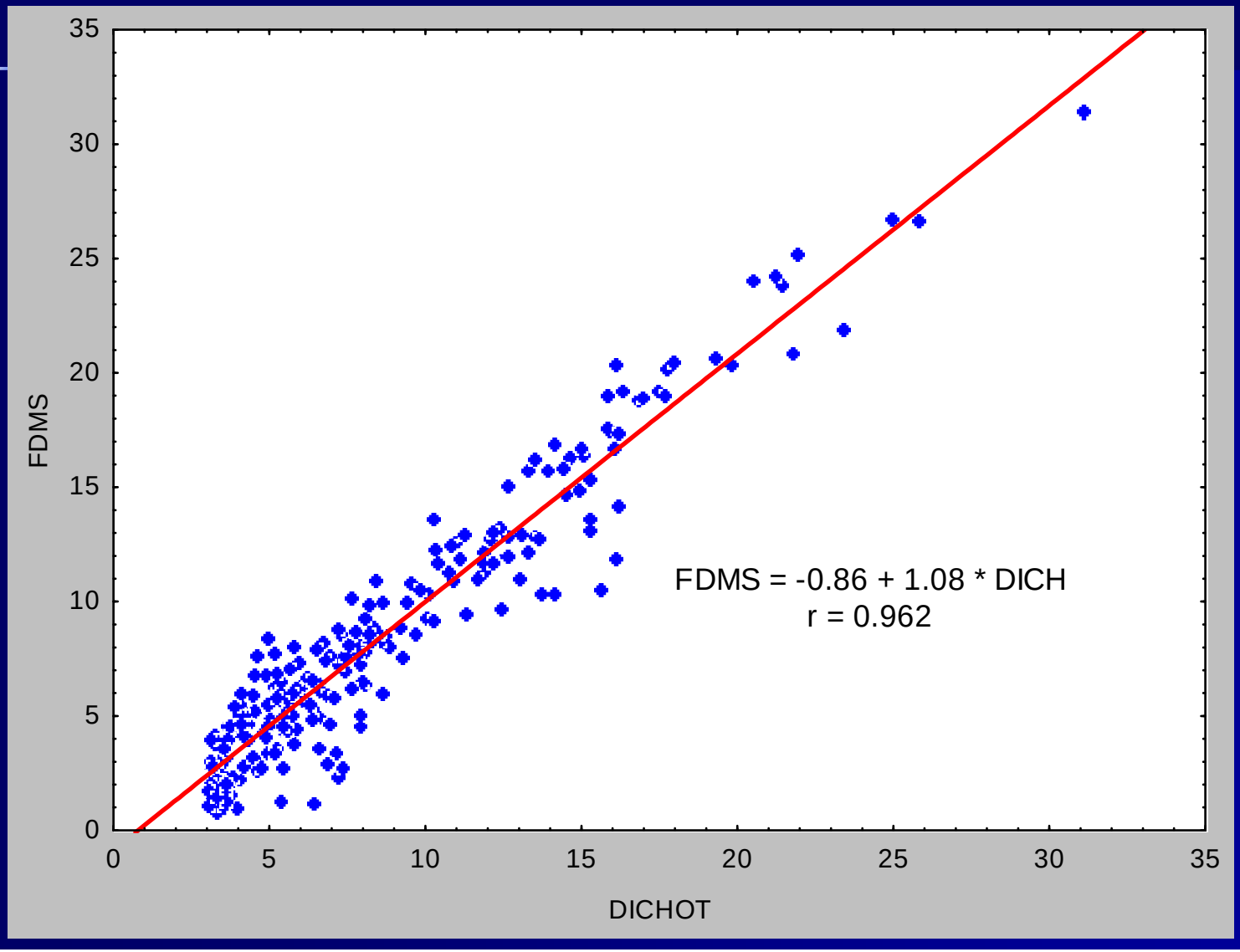
Linear regression results for 24h data
BAM 2x Ottawa (2007 - 2008)



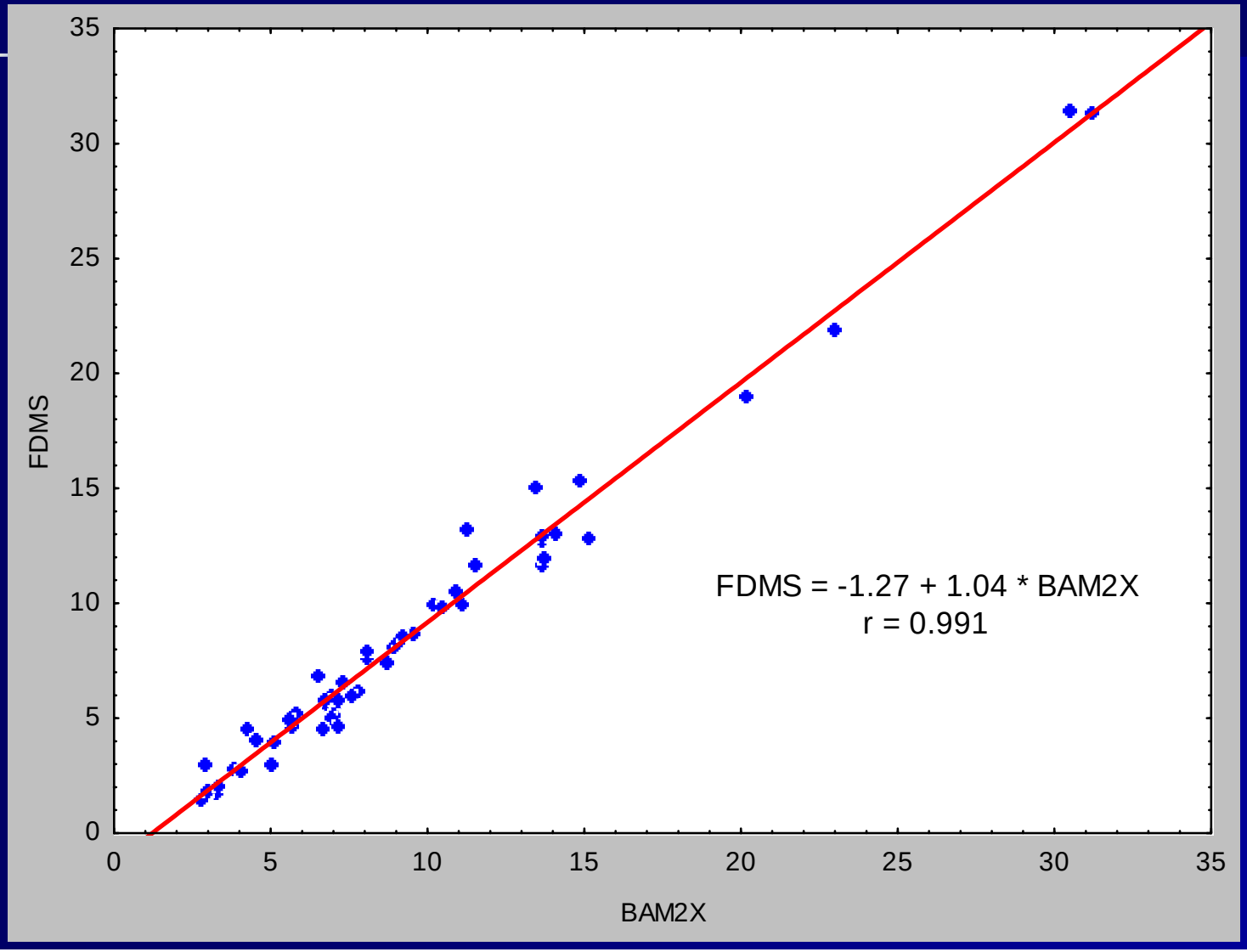
Linear regression results for 24h data
BAM 1020 Ottawa (Nov 2006 - Jan 2008)



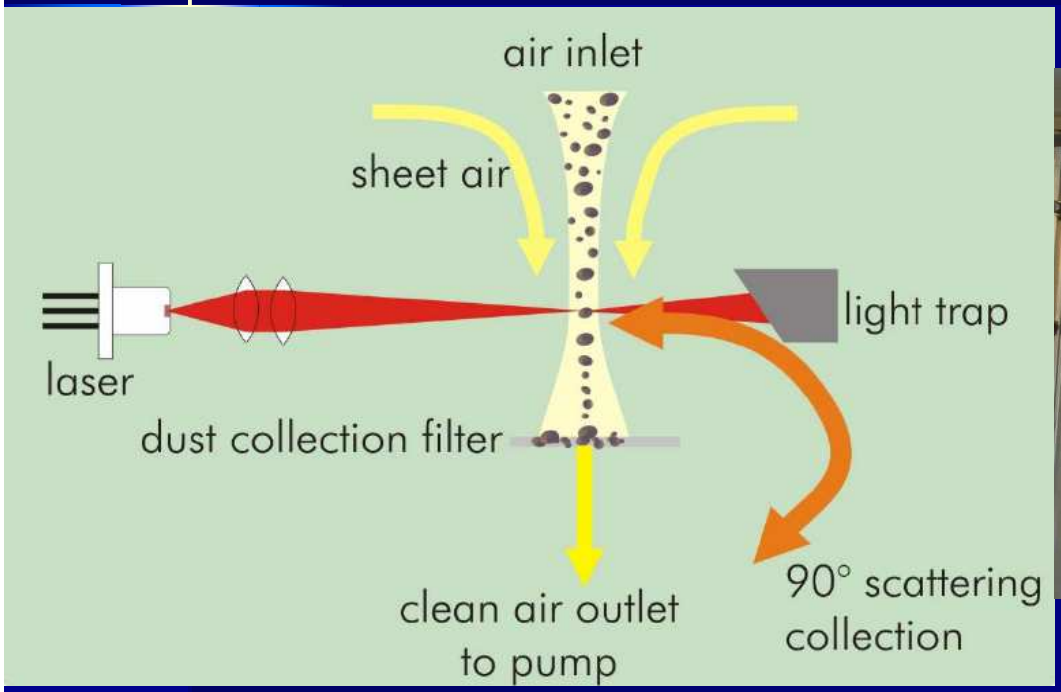
Linear regression results for 24h data
TEOM-FDMS Ottawa (2006-2008 All Data)



TEOM-FDMS vs. BAM1020(2x) Ottawa (2007 - 2008 All Data)

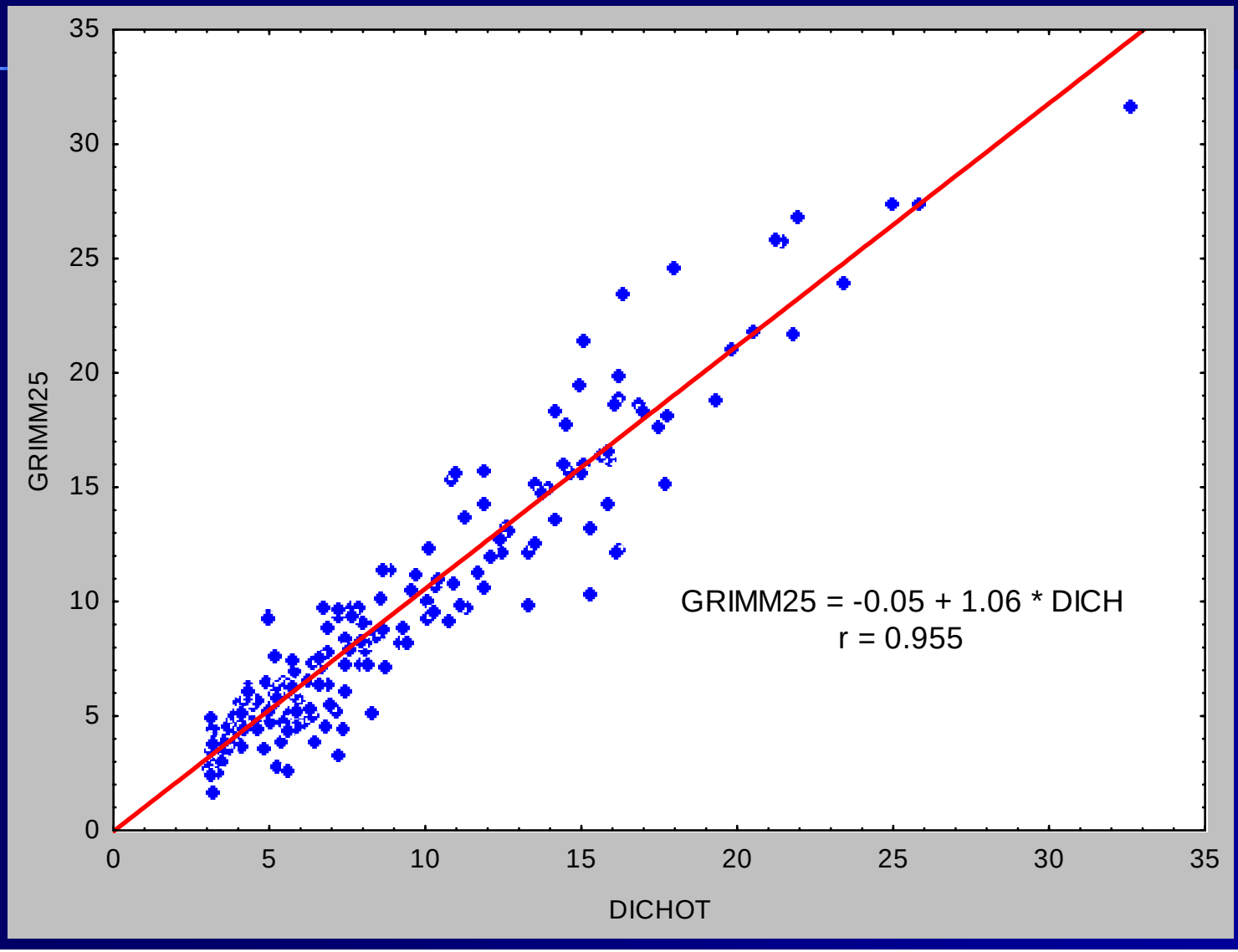


Grimm 180 Multi-channel Aerosol Spectrometer

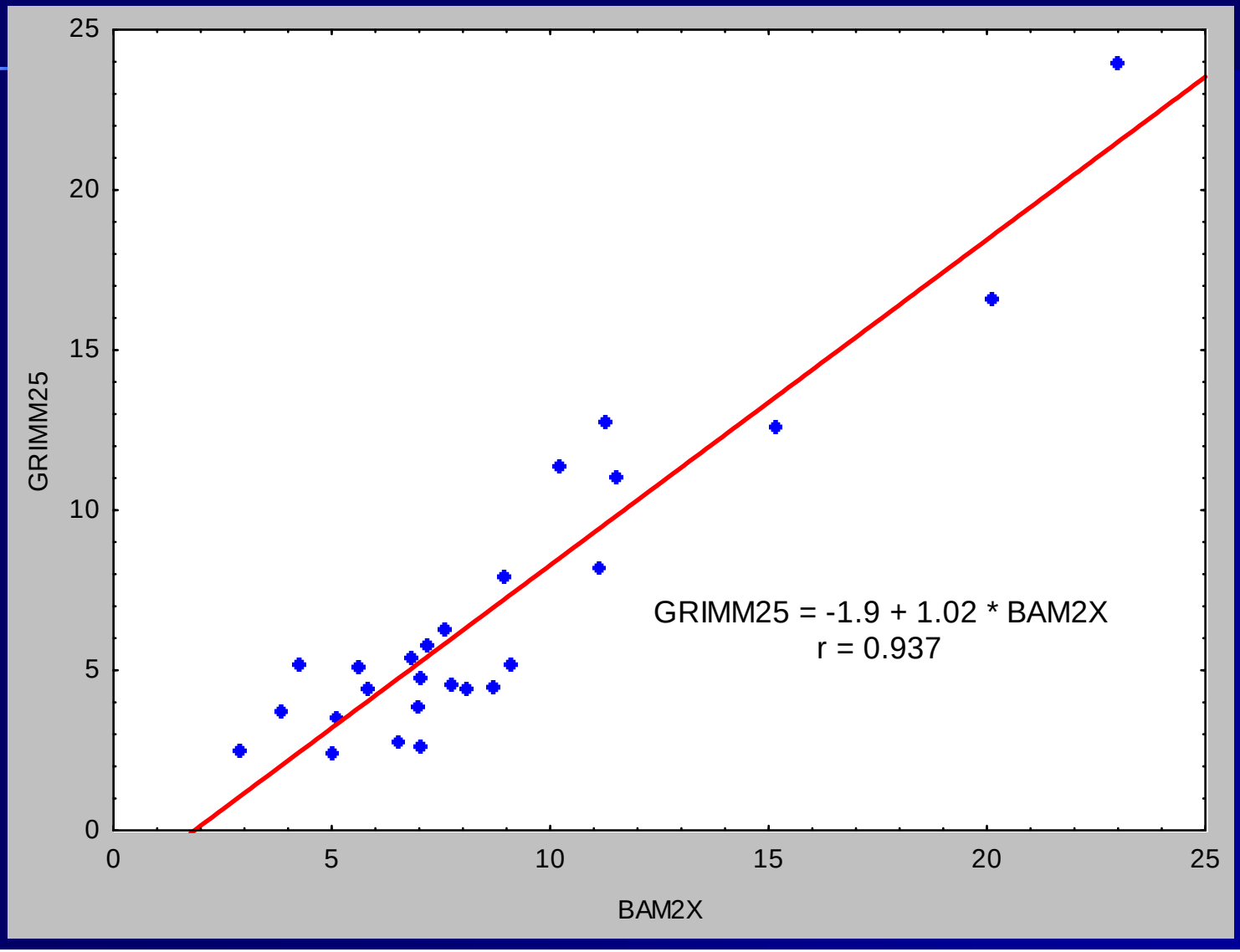


Simultaneous measurement of $PM_{1.0}$, $PM_{2.5}$ and PM_{10}
Particle counts by size (31 channels) and mass determination using algorithms
No size cut on inlet – moisture control using Nafion dryer
Truly continuous (real-time)

Results for 24h $PM_{2.5}$ data: Grimm 180 (Ottawa) Jan. 2006 – Dec. 2007



Grimm 180 vs. BAM1020(2x) (Ottawa) July 2006 – Dec. 2007

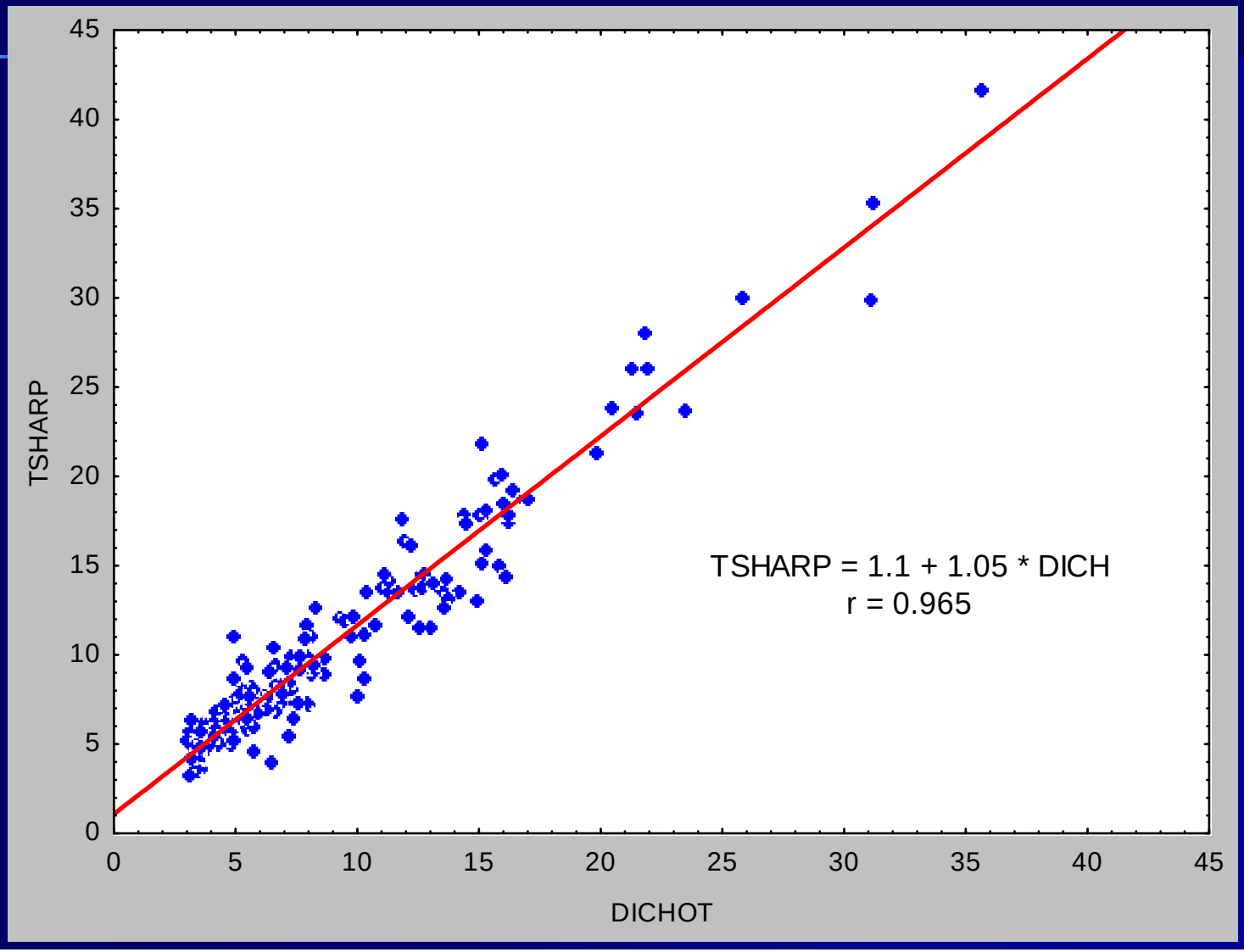


Thermo SHARP 5030

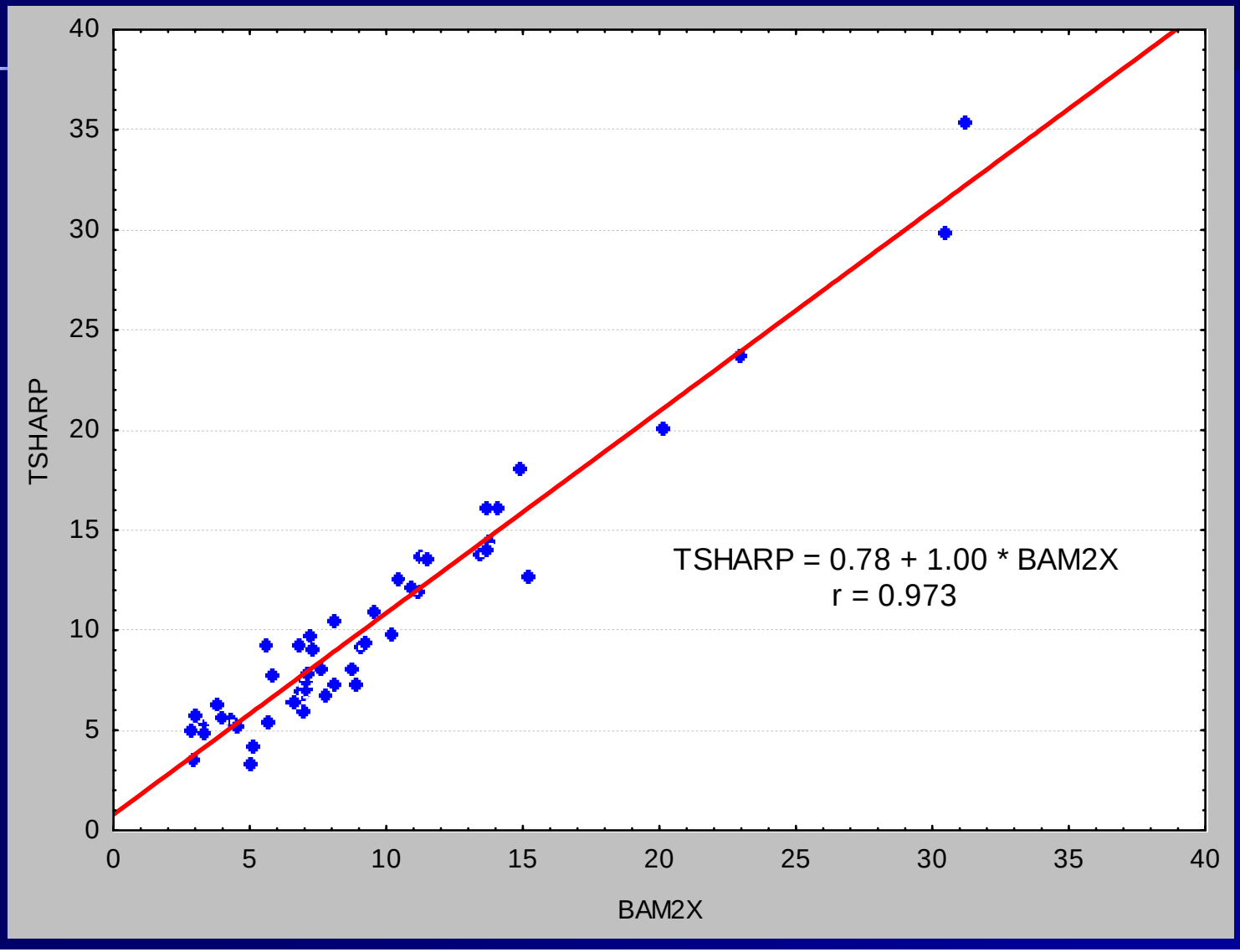
Synchronized Hybrid Ambient Real-time Particulate Monitor

- Truly continuous (real-time)
- Combination nephelometer & beta-ray attenuation
- Light scattering photometer is continuously calibrated by beta attenuation mass sensor
- Intelligent Moisture Reduction (IMR) System heating the inlet tube; threshold is set at 40%

Linear regression results for 24h data: Sharp 5030 (Ottawa June 2006 – Jan. 2008)



Sharp 5030 vs. BAM1020(2x) (Ottawa July 2007 – Jan. 2008)



Cost Comparisons for Continuous $PM_{2.5}$ Instruments (2007 Canadian$):

Met-One BAM 1020	$23,300
Thermo TEOM 1405	$22,000
Thermo 8500 FDMS Kit	$10,700
TEOM-FDMS 1405-F	$31,300
GRIMM 180 (PM_{10}, $PM_{2.5}$, $PM_{1.0}$)	$34,000
Thermo SHARP 5030	$26,500

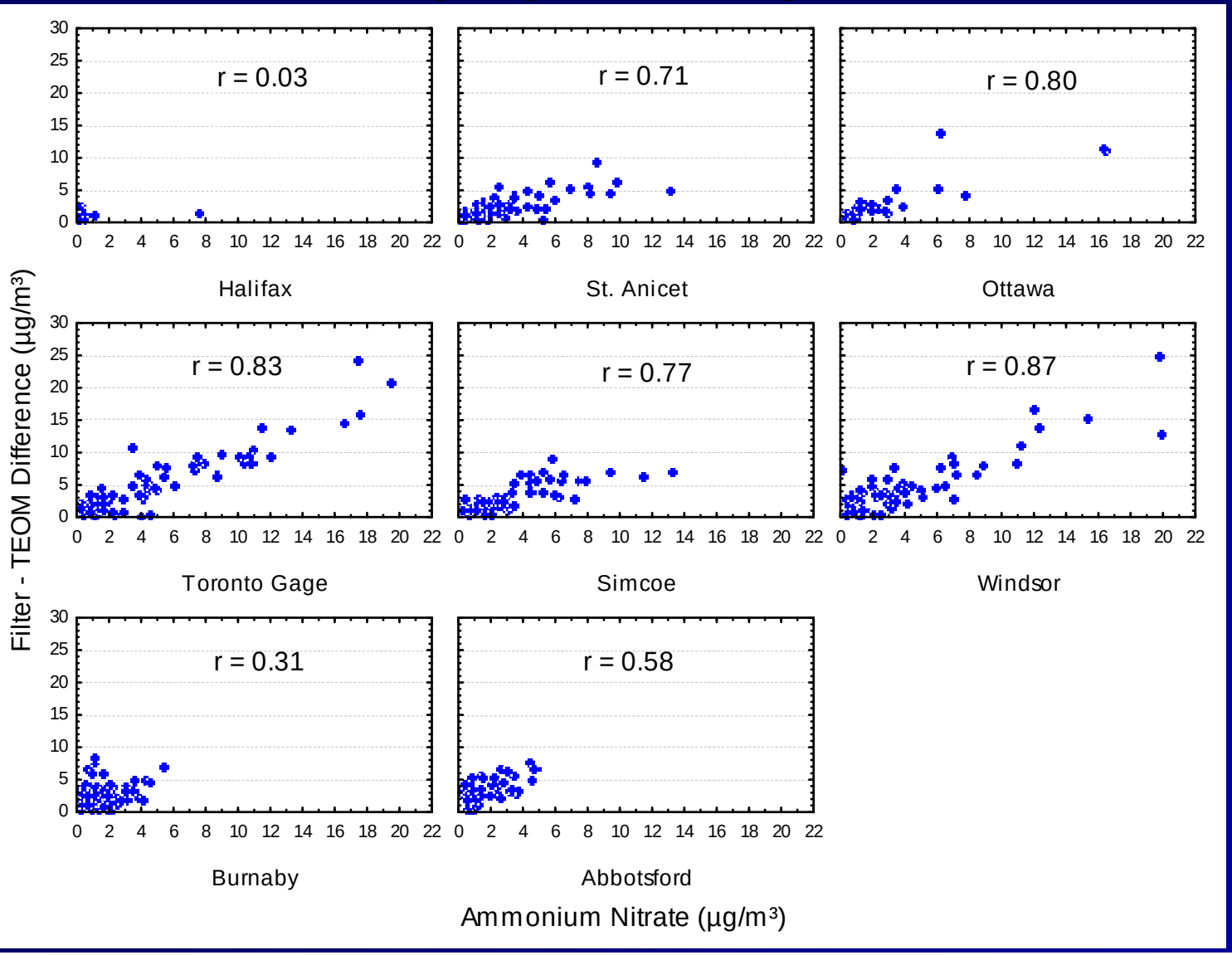
2007 Instrument Performance in Ottawa Based on EPA ARM Template

Instrument	N	Slope	Intercept	r
TEOM-SES	133	0.80	0.04	0.940
TEOM-FDMS	98	1.06	-0.96	0.966
BAM1020(2x)	52	0.97	1.12	0.984
GRIMM	98	1.08	-0.26	0.962
SHARP	98	1.07	1.07	0.969

TEOM-SES and TEOM40

- Can results be transformed and meet ARM requirements ????
- If so:
  - temperature adj.?
  - Julian Day?
  - Other?

Relationship between Ammonium Nitrate and Mass Difference (Days < 10°C)



The Black Box (a.k.a The Fudge Factor)

- $C/[(1-0.03(L- R\ P / T[12.798 – 18.393e^{(5423((1/273)-(1/T)))} / (P - 6.11e^{(5423((1/273)-(1/T)))})]e^{(5423((1/273)-(1/T)))} / (P - 6.11e^{(5423((1/273)-(1/T)))}))(1-(F-15)/250)]$

- Where:
- C = Initial $PM_{2.5}$ concentration
- L = water content in the lab (about 8.7 g/m^3 for Ottawa))
- P = Atmospheric pressure (hPa)
- F = percent filter load (%)
- R = Relative humidity (%)
- T = Temperature (K)

Theory courtesy of Dennis Fudge, B.C. Ministry of Environment

The Amount of Moisture in the Atmosphere

$$PM2.5 = C / [(1-0.03(L-W))(1-(F-15)/250)]$$

Where:

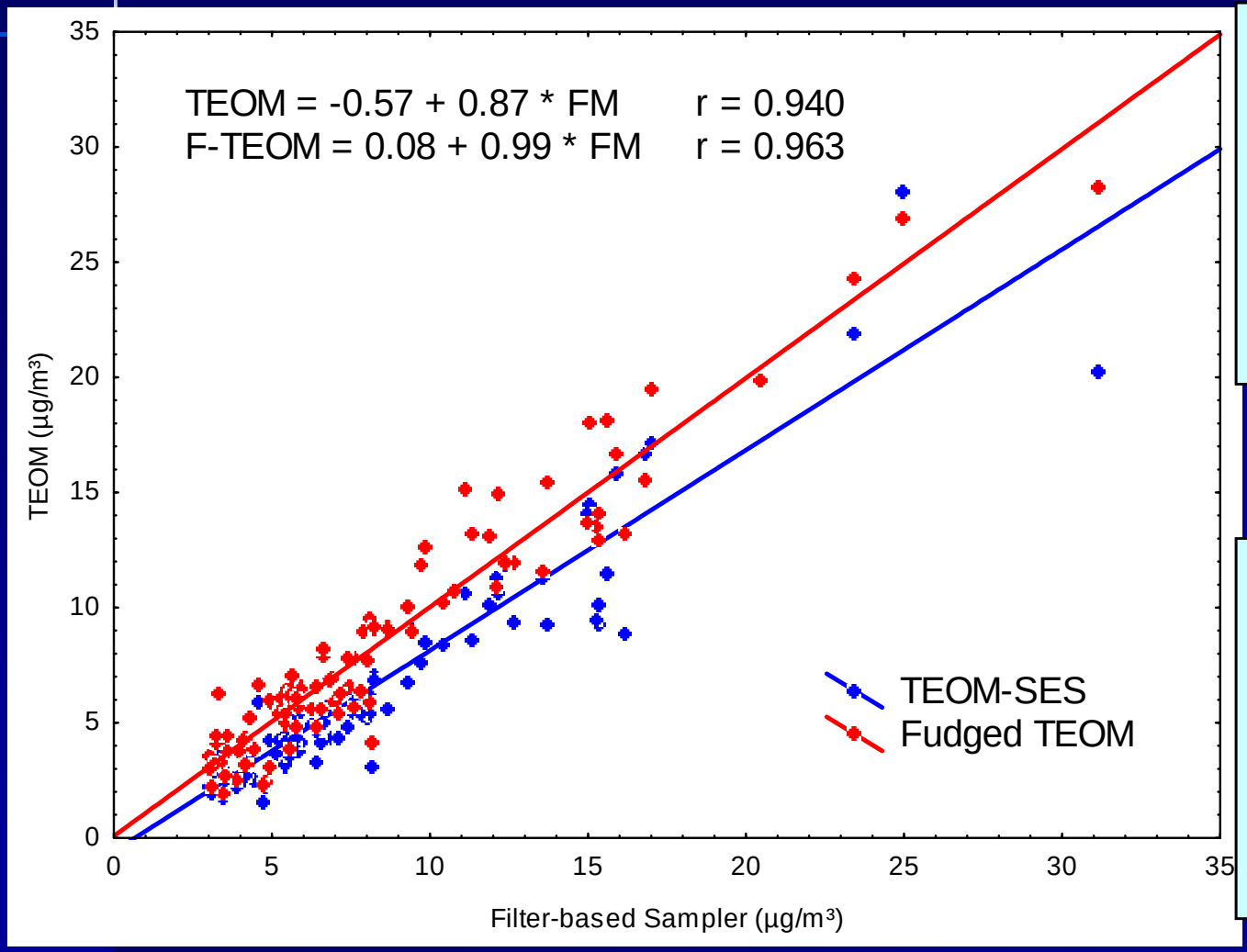
C = Initial $PM_{2.5}$ concentration
L = water content in the lab (about 8.0 g/m^3)
F = percent filter load (%)
W = water content in the ambient air (this depends on the temperature, relative humidity and atmospheric pressure)

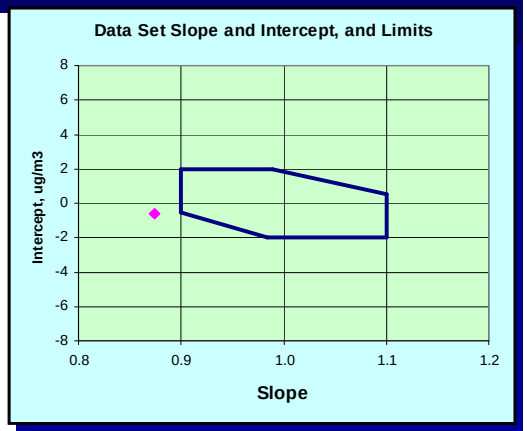
$$W = (R\ P/T)[12.798 – 18.393K / (P - 6.11K)](K / (P - 6.11K))$$

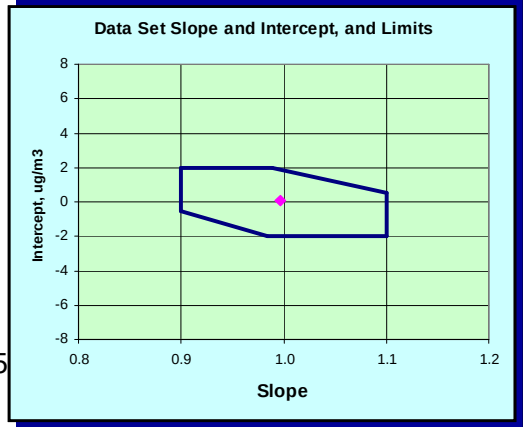
Where:

- P = Atmospheric Pressure (hPa)
- T = Temperature (K)
- R= Relative Humidity (%)
- $K = e^{(5423*((1/273)-(1/T)))}$

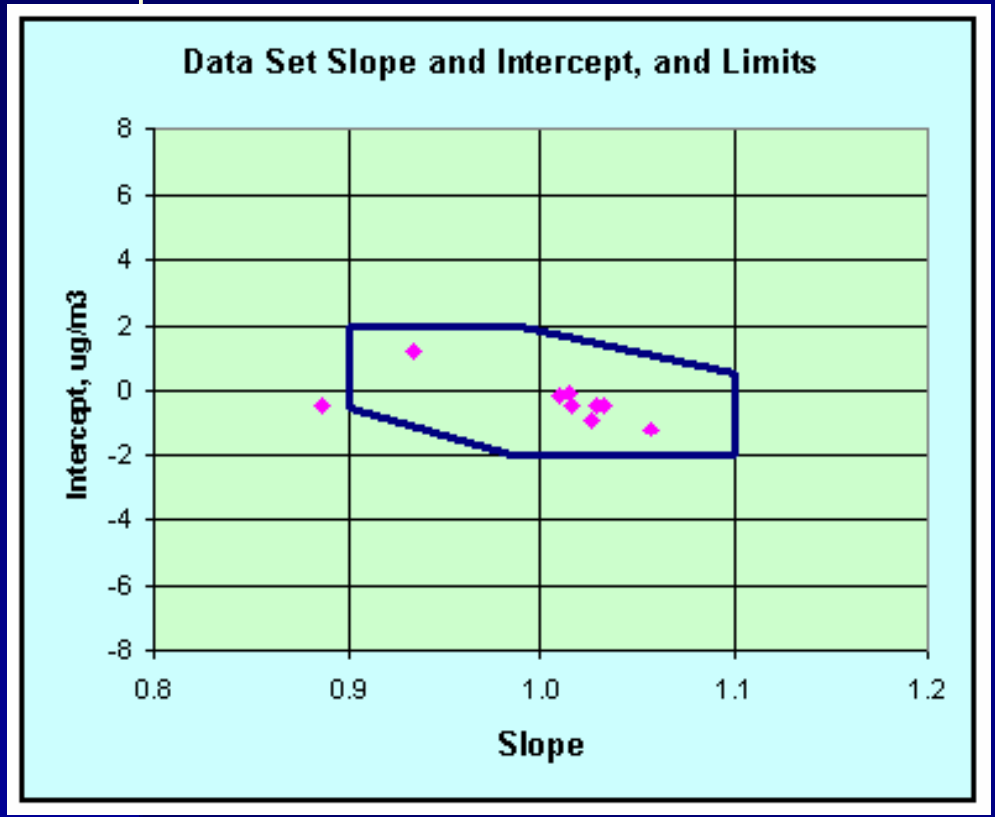
Effect on Ottawa TEOM-SES (2007)







Effect on TEOM40 and TEOM-SES at B.C. Sites (2007)



Site	Correlation (r)
Abbottsford	0.94
Burnaby	0.90
Prince George	0.97
Prince George Plaza	0.98
Vancouver	0.81
Smithers	0.96
Williams Lake	0.96

Theory courtesy of Dennis Fudge, B.C. Ministry of Environment