Receptor modelling of boreal wildfire associated $PM_{2.5}$ in Halifax, Nova Scotia, Canada

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Aim & Objectives

To apportion the source contribution from boreal forest wild fire smoke (and other sources) to the total $PM_{2.5}$ mass concentration in Halifax during the BORTAS-B project.

Materials & Methods

45 days of contiguous $PM_{2.5}$ filter samples were collected in Halifax between 11/07/11 & 25/08/11 (Palmer et al., 2013). Fig 1 provides the location of the Dalhousie Ground Station (DGS). To help identify upwind source regions, NOAA HYSPLIT 2-day air mass back trajectories were run twice per day, together with local meteorological measurements. An ensemble HYSPLIT plot of the 2-day back trajectories by source sector is presented in Fig. 2 (cyan = marine aerosol, red = NE US, green = Windsor-Québec corridor Canada, blue = Northern Canada). The $PM_{2.5}$ mass concentration and species sampling equipment used at the DGS is shown in Fig 3.

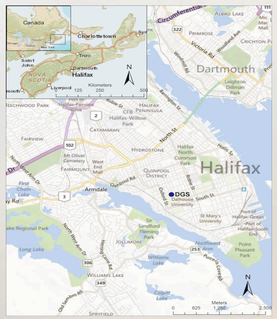


Fig. 1 DGS Monitoring Site

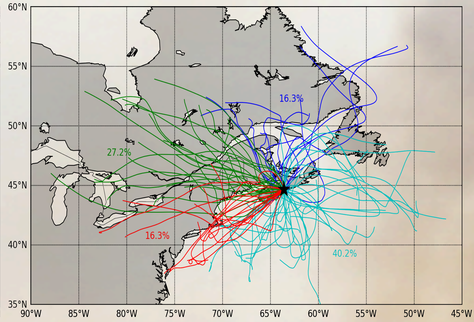


Fig. 2 HYSPLIT ensemble air mass back trajectories

The 24-hr $PM_{2.5}$ mass concentration was determined by gravimetric analysis of the teflon filter. The teflon filter was also analyzed by ED-XRF (Thermo Quant' X) and ICP-MS (Thermo X-Series II) for 33 water soluble metals. The nylon filter was analyzed by ion chromatography (Thermo Dionex ICS-1000) for water soluble Na^+, NH_4^+, Cl^-, NO_3^- and SO_4^{2-} (Gibson et al., 2013). The woodsmoke chemical source marker levoglucosan was measured by GC-MS following derivatization.

Four receptor models were used to apportion the $PM_{2.5}$ samples: pragmatic mass closure (PMC) (Harrison et al., 2003), absolute principal component scores (APCS) (Thurston & Spengler 1985), USEPA Positive Matrix Factorization v3.0 (PMF) (Gibson et al., 2013) and USEPA Chemical mass Balance v8.2 (Ward et al., 2012). The PMF and CMB results are presented here. The PMC and APCS receptor model results will be presented during session AS4.11/BG2.19/NH7.3, EGU2013-11402.

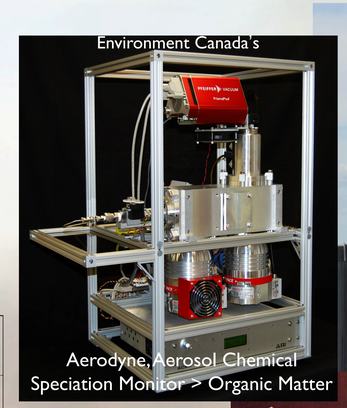
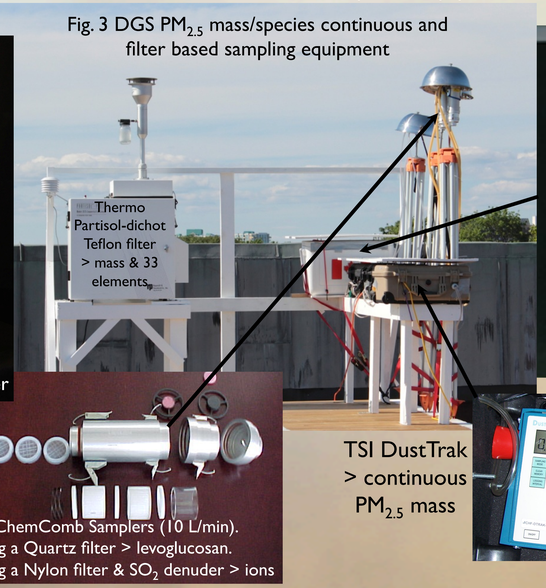
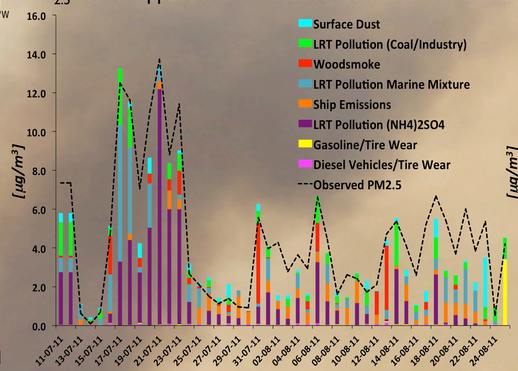


Fig. 3 DGS $PM_{2.5}$ mass/species continuous and filter based sampling equipment



Results

$PM_{2.5}$ source apportionment time series of the PMF and CMB receptor model results are shown in Fig 4.



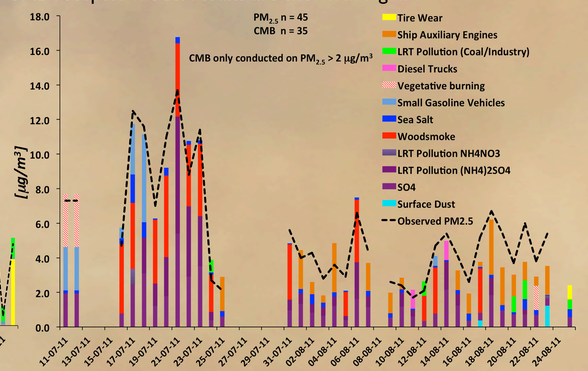


Fig 4. Time series of PMF (left) and CMB (right) $PM_{2.5}$ source apportionment modelling results

The table below presents the observed $PM_{2.5}$, PMF (left) and CMB (right) receptor model descriptive statistics.

Metric	n	Mean	Median	Min	Max	Std Dev	CI
Observed $PM_{2.5}$	45	4.57	4.04	0.08	13.73	3.39	0.98
Diesel Vehicles/Tire Wear	39	0.05	0.03	0.00	0.17	0.04	0.01
Gasoline/Tire Wear	30	0.14	0.02	0.00	3.43	0.62	0.22
LRT Pollution $(NH_4)_2SO_4$	33	2.05	1.15	0.09	12.12	2.45	0.84
Ship Emissions	34	0.55	0.49	0.04	1.15	0.31	0.11
LRT Pollution Marine Mixture	38	0.88	0.44	0.02	7.00	1.31	0.42
Woodsmoke	29	0.61	0.14	0.00	4.14	1.00	0.36
LRT Pollution (Coal/Industry)	34	0.74	0.48	0.00	2.97	0.69	0.23
Surface Dust	38	0.33	0.19	0.00	2.55	0.44	0.14

Metric	n	Mean	Median	Min	Max	Std Dev	CI
Observed $PM_{2.5}$	45	4.57	4.04	0.08	13.73	3.39	0.98
Surface Dust	2	0.81	0.81	0.39	1.24	0.6	0.83
LRT Pollution (Coal/Industrial)	5	0.83	0.85	0.57	1.09	0.2	0.17
Woodsmoke	14	3.23	3.59	1.38	4.72	1.04	0.54
Marine Aerosol	34	0.3	0.24	0.04	1.64	0.3	0.1
Ship Auxiliary Engines	17	1.43	1.2	0.3	3.2	0.84	0.4
LRT Pollution $(NH_4)_2SO_4$	21	1.45	0.67	0.24	6.77	1.58	0.68
Tire Wear	1	0.82	0.82	0.82	0.82	NA	NA
Diesel Trucks	2	1.11	1.11	1.1	1.12	0.02	0.02
Vegetative Burning	2	2.25	2.25	1.42	3.08	1.18	1.63
Small Gasoline Vehicles	5	2.35	2.51	0.58	5.08	1.87	1.63
LRT Pollution NH_4NO_3	2	0.54	0.54	0.14	0.94	0.57	0.79
SO_4	35	1.31	0.95	0.35	5.4	1.08	0.36

Fig 5 provides the predicted average mass and % source contribution to the total $PM_{2.5}$ sampled during BORTAS-B.

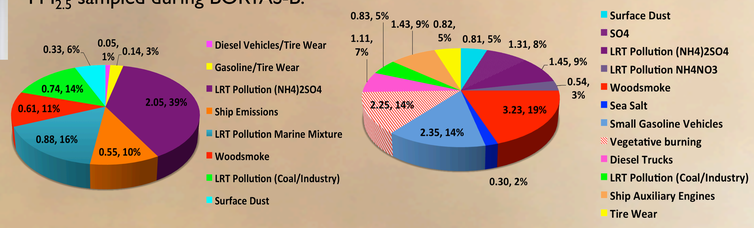


Fig 5. PMF (left) and CMB (right) predicted average mass and % source contribution to $PM_{2.5}$ sampled during BORTAS-B.

Discussion & Conclusion

8 $PM_{2.5}$ sources (inc. woodsmoke) were identified by PMF. CMB identify 12 sources, two of which were biomass combustion related (woodsmoke and vegetative burning). However, the vegetative burning only occurred on 2 days and not associated with woodsmoke. The $PM_{2.5}$ samples unambiguously associated with woodsmoke (presence of levoglucosan) were associated with air flow from the W and NW (green trajectories in Fig 2.). GEOS-Chem (CO), FLEXPART, LIDAR and MODIS fire products (FLAMBE) confirmed the transport of boreal wild fire smoke over Halifax during these sampling periods, lending further support to the PMF model results. The PMF & CMB woodsmoke mass (%) source contribution to $PM_{2.5}$ during BORTAS-B was found to be 0.61 ± CI 0.36 µg/m³ (11 %) and 3.23 ± CI 0.54 µg/m³ (19 %) respectively. CMB over predicted the $PM_{2.5}$-woodsmoke mass by 5.3 when compared to PMF. Because of the presence of levoglucosan, PMF can be considered as the more robust of the two models at predicting biomass burning $PM_{2.5}$-woodsmoke. Both the PMF and CMB receptor models provided further insight into the boreal wild fire smoke and other major source contributions to the $PM_{2.5}$ mass sampled during the BORTAS-B campaign.

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Photo courtesy of James Kuchta

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