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Organic aerosols in relation to small-scale wood combustion, forest fires and traffic

R. Hillamo, S. Saarikoski, H. Timonen, K. Saarnio, A. Frey, M. Aurela

Finnish Meteorological Institute, Helsinki, Finland

L. Järvi, M. Kulmala

University of Helsinki, Helsinki, Finland

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Measurements

Site

- **SMEAR III** (60°20'N, 24°97'E), urban background
- Local sources: traffic, biomass combustion
- Long-range transport ~50% of PM2.5, frequent wild fire plumes

Period shown here

- June 2006–February 2007

SMEAR III belongs to the European ACCENT network
– access to field and laboratory infrastructures

Identification of sources –different approaches

Time resolution 24-48 h

- Needs long-term measurements + large sets of chemical components → seasonal (annual) cycles

Time resolution < 3 h (for several components)

- Diurnal variations, good timing for specific episodes (pollution or clean)
- Excellent data for modellers,epidemiological studies and for statistical methods (e.g. PMF)

Same observations at several sites

- Helsinki (urban)
- Hyytiälä (rural forest)

Methods

Sampling (24 h)

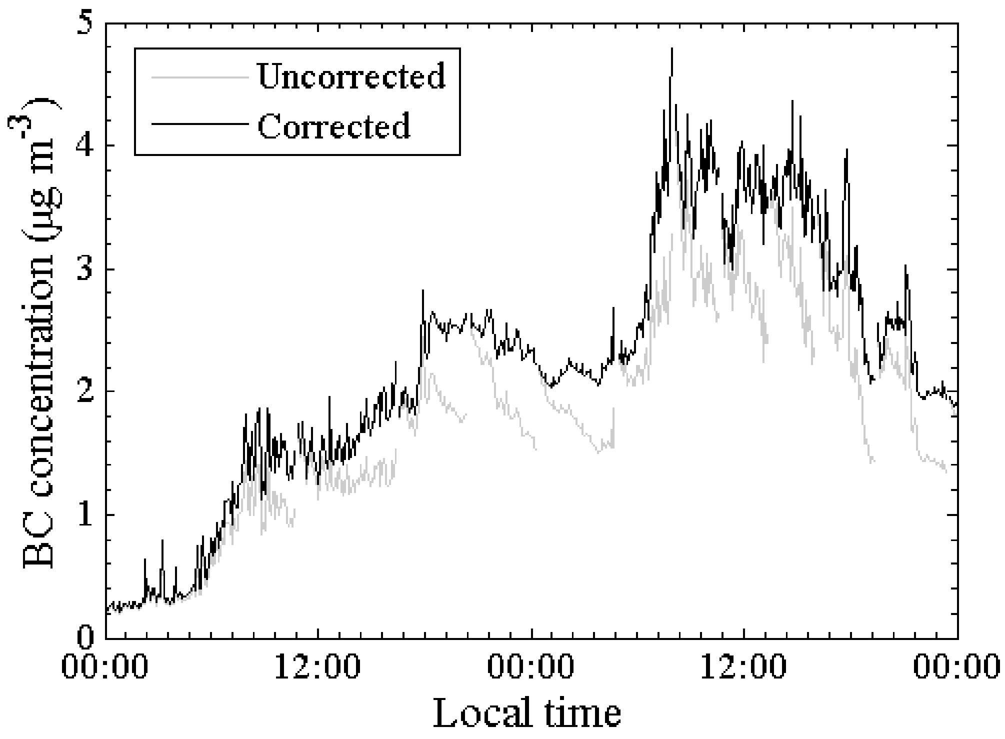
- PM_1 filter sampling (80 lpm, 47 mm filter)
- Analytical techniques: IC, TOC, LC/MS, TOT (Sunset lab)

Online/real-time (1 s – 3 h)

- PILS-IC for ions (15 min)
- PILS-Total organic carbon analyzer for WSOC (5 min)
- Semicontinuous EC/OC (Sunset Lab, 1-3 h)
- Aethalometer (black carbon, 5 min)
- PSAP (aerosol absorption, 1 s)
- Twin-TEOM (PM_1, PM_{1-10}, 30 min)
- DMPS, APS (particle number size distribution, 10 min)
- O_3, NOx, CO
- Meteorology

Site comparison (Helsinki/urban – Hyytiälä/rural, distance 200 km)

Black carbon (soot) data from Helsinki 1996-2005



- Correction of BC data (Virkkula et al., 2007)
- Selection of periods to be compared (1996-1997, 2000-2001, 2004-2005)

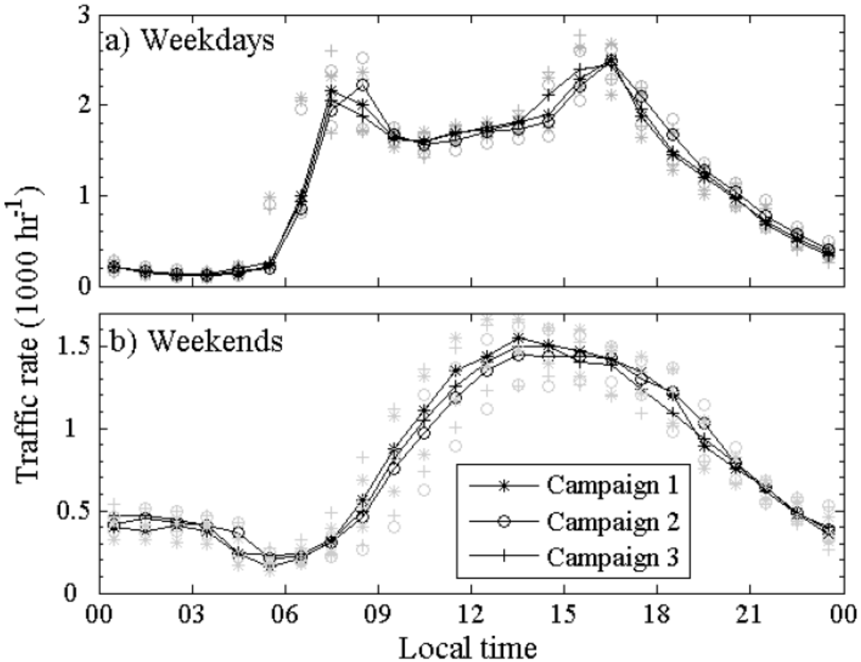
Virkkula et al. (2007) A Simple Procedure for Correcting Loading Effects of Aethalometer Data, *J. Air & Waste Manage. Assoc.* ***57****:1214–1222*

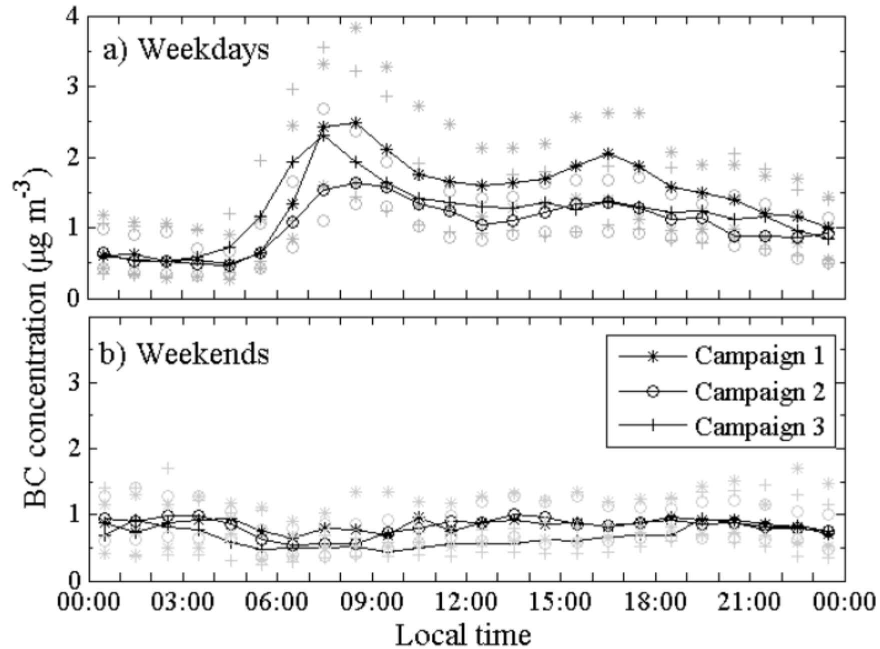
Black carbon ($PM_{2.5}$) in Helsinki 1996-2005: concentrations ($\mu g/m^3$) during comparable periods

Period	Campaign 1 (1996 - 1997)	Campaign 2 (2000 - 2001)	Campaign 3 (2004 - 2005)
P1	1.43 (0.62)	0.95 (0.35)	1.12 (0.71)
P2	1.14 (0.54)	0.97 (0.36)	0.68 (0.46)
P3	1.11 (0.61)	0.92 (0.40)	1.04 (0.56)
P4	0.86 (0.54)	0.90 (0.51)	1.05 (0.50)
All	**1.11 (0.60)**	**0.93 (0.40)**	**1.00 (0.56)**

Järvi et al. (2007) Atmos. Chem. Phys. Discuss., 7, 14265–14294

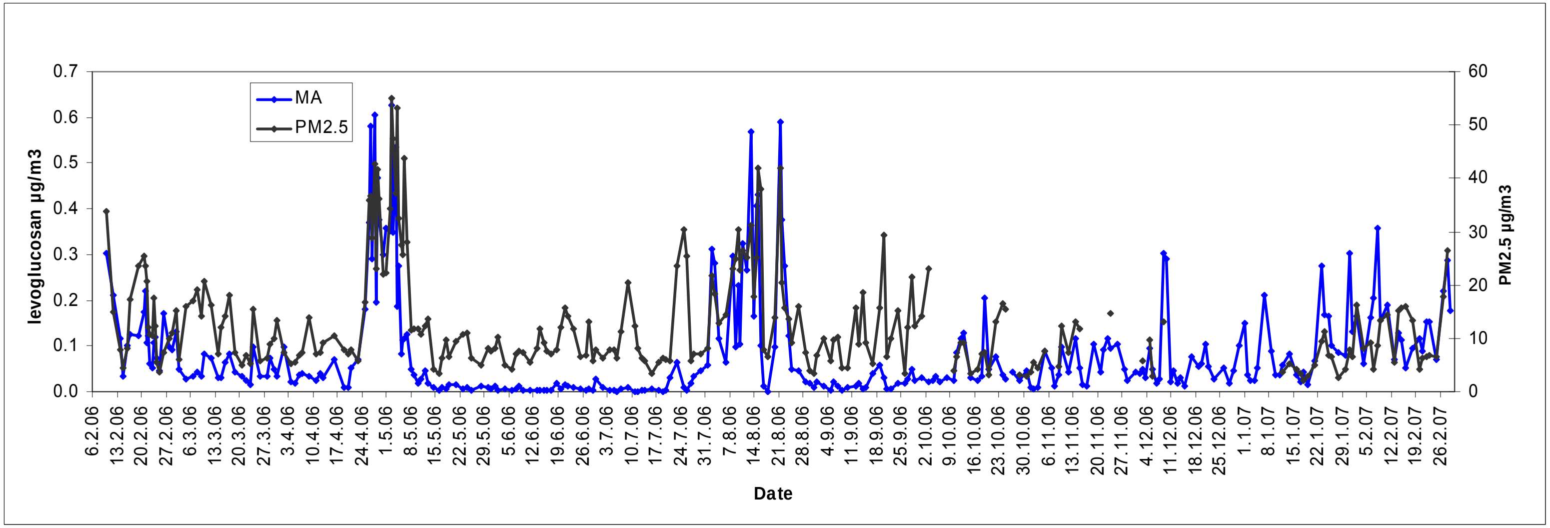
Traffic intensity vs. BC concentrations

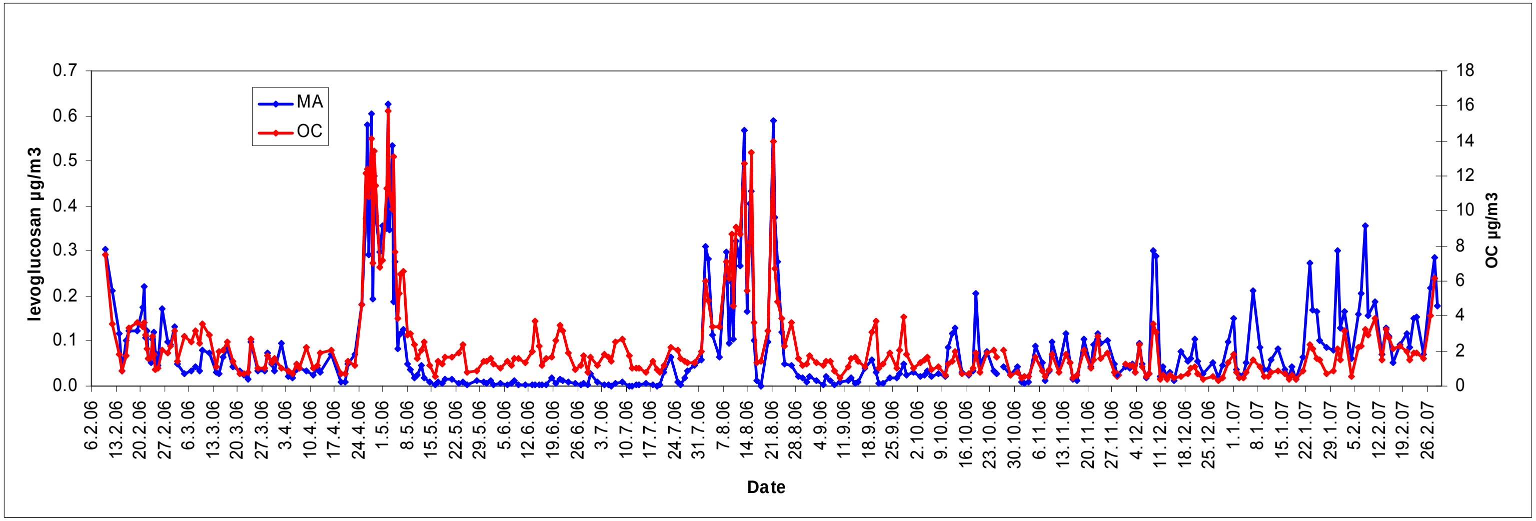




Järvi et al. (2007) Atmos. Chem. Phys. Discuss., 7, 14265–14294

$PM_{2.5}$ from wood combustion and wild fires





MA= monosaccharide anhydrates= sum (levoglucosan+mannosan+galactosan)

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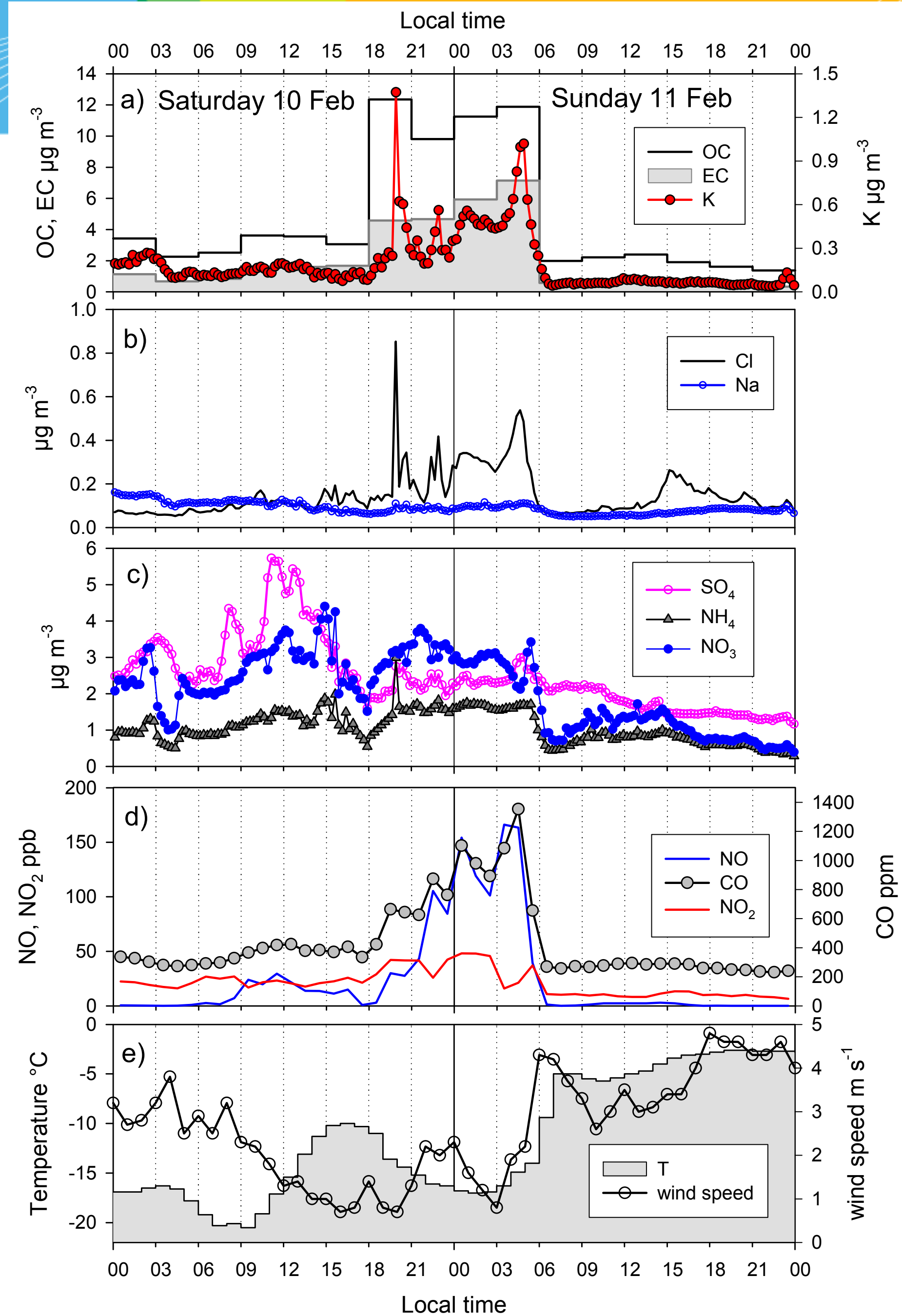
Wood combustion

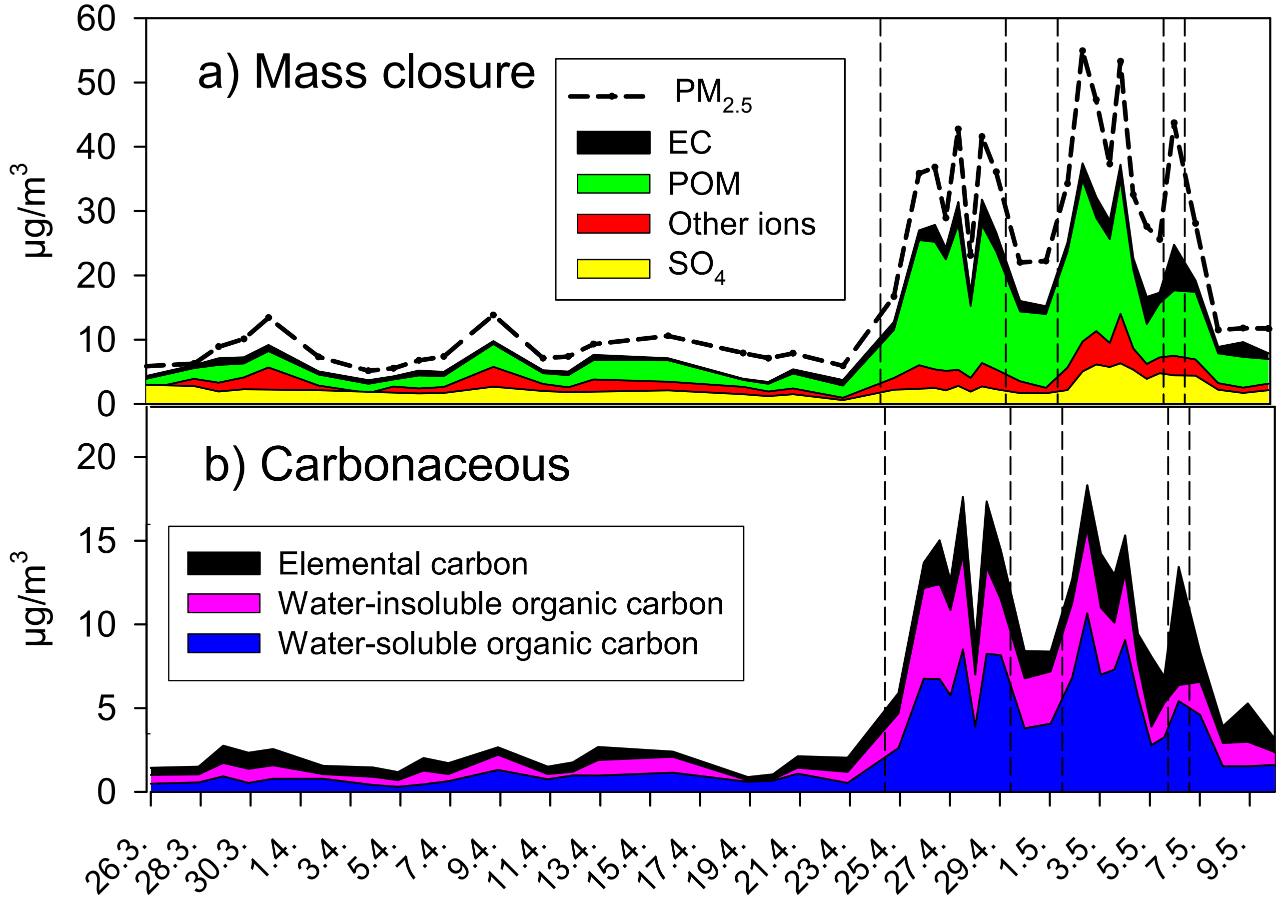
Online measurements of PM_1 chemistry

- time resolution 15 min-3h
- 9 months campaign

Saarikoski S. et al., 2008, Atmospheric Chemistry and Physics, submitted

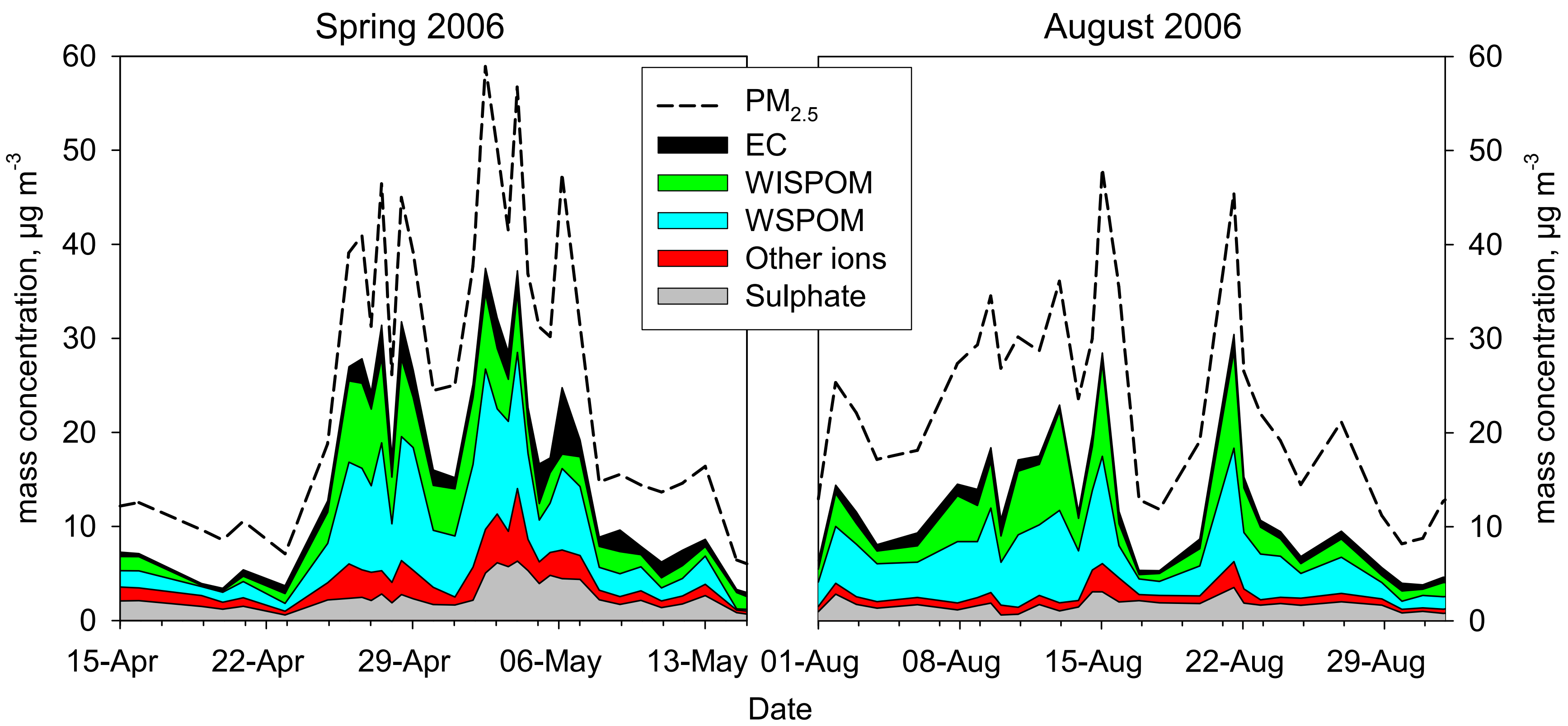


Wild fire spring 2006: mass closure study



Saarikoski et al. (2007). Chemical composition of aerosols during a major biomass burning episode over northern Europe in spring 2006: Experimental and modelling assessments. *Atmos. Environ.* 41:3577-3589**.**

From filter sampling



Episode in spring 2006.

Episode in August 2006.

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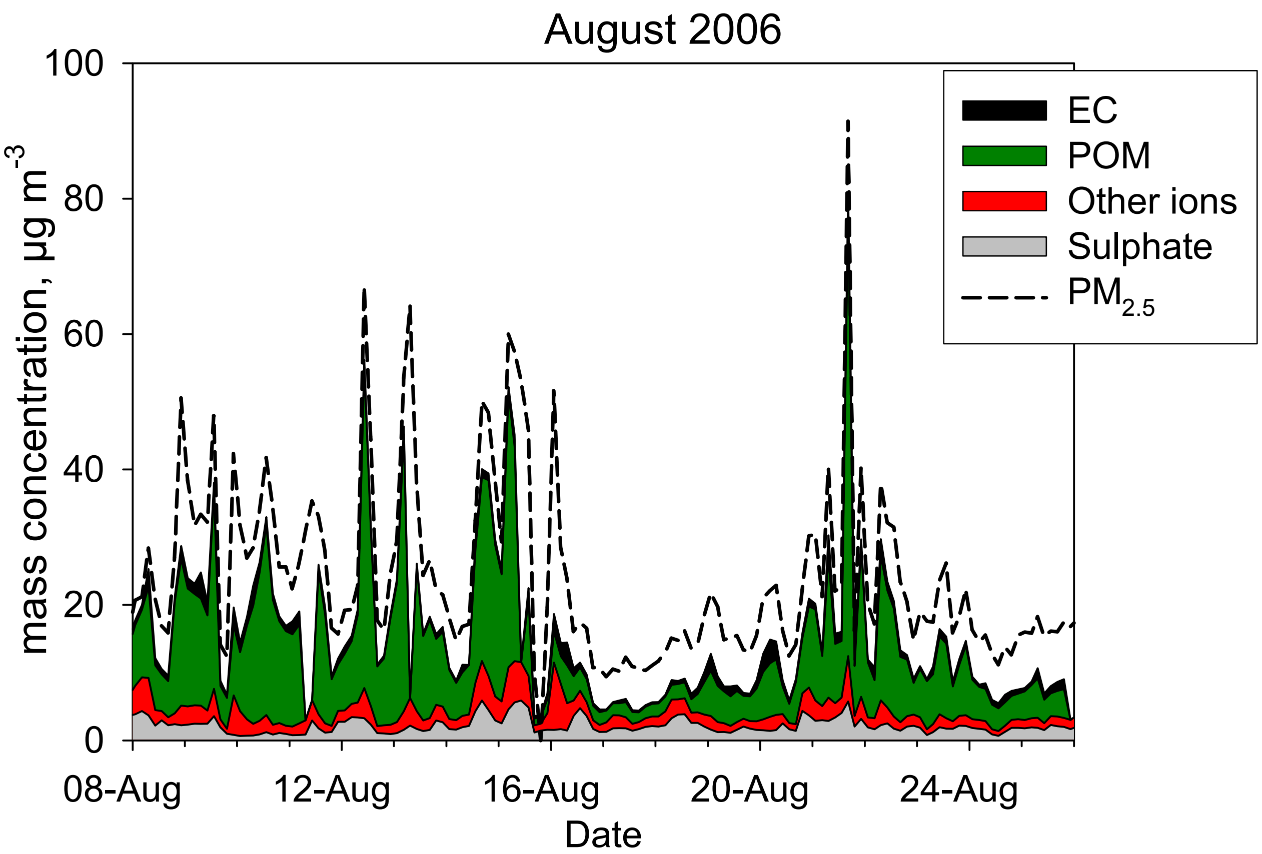
From on-line measurements



August episode with 3-hour time-resolution

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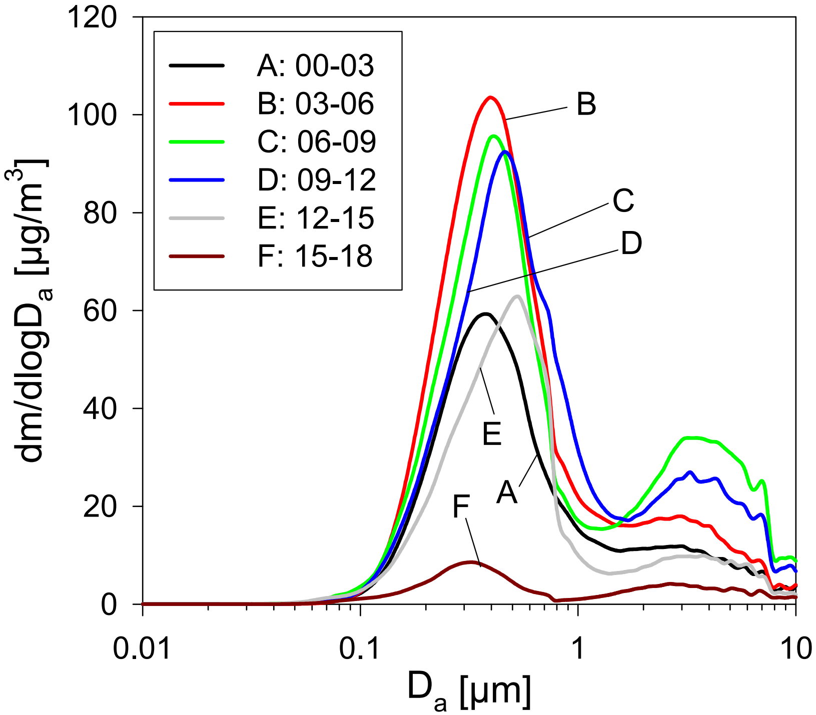
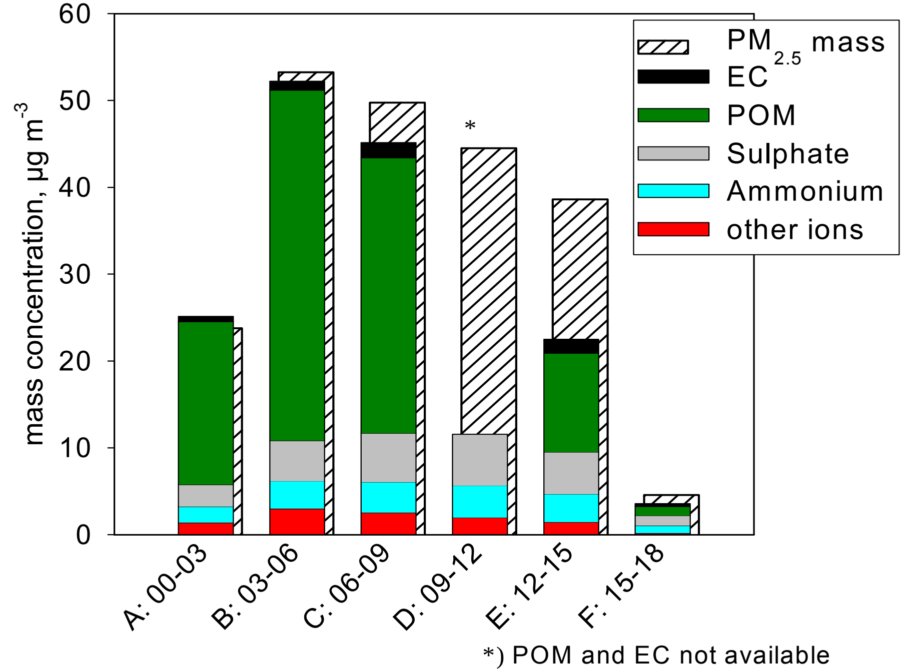
Wildfire: August 15, 2006



3-hour mass size distributions (A-F) during the progress of the plume on August 15, 2006.
(F represents a non-plume situation.)



The $PM_{2.5}$ mass and chemical composition of PM_1 on August 15, 2006 with 3-hour time-resolution.

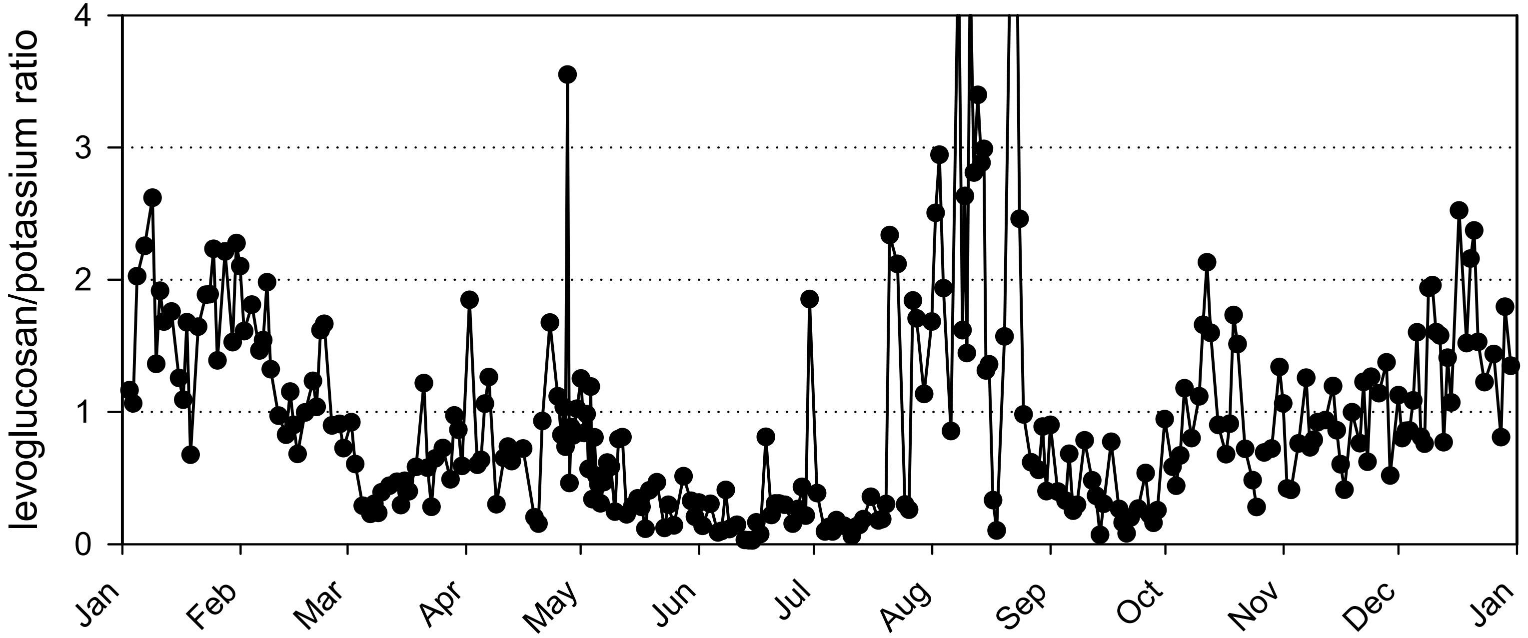
Biomass burning tracers

- Spring episode: April 24 – May 7, 2006
- August episode: August 1 – August 28, 2006
- Plume samples have been chosen according to the high content of levoglucosan

	K/Levoglucosan	K/Oxalate	Oxalate/Levoglucosan
Spring episode	**1.04**	0.85	1.28
August episode	1.02	0.31	5.13
Plumes of August episode	**0.32**	0.32	1.03
”Non-plume”-samples	1.71	0.29	9.22

Spring flaming, August plumes smoldering fires

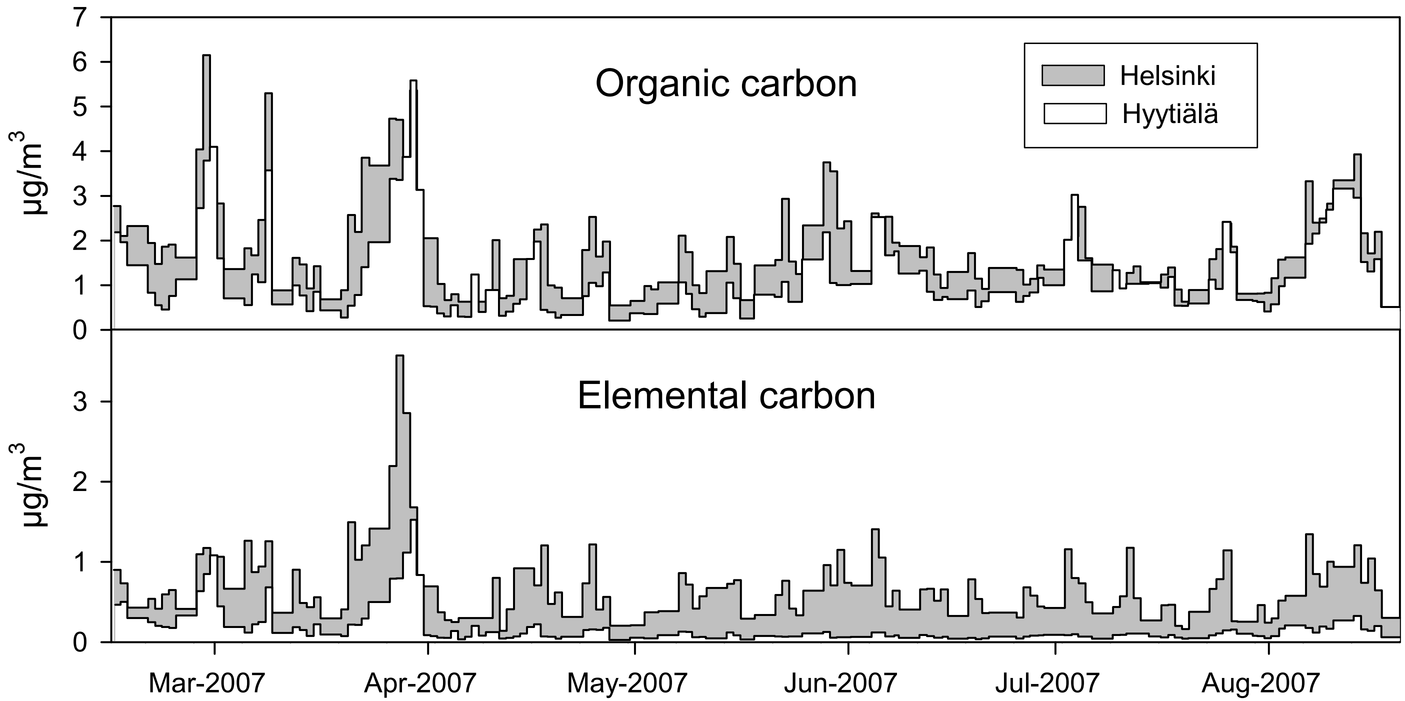
Levoglucosan/potassium ratio



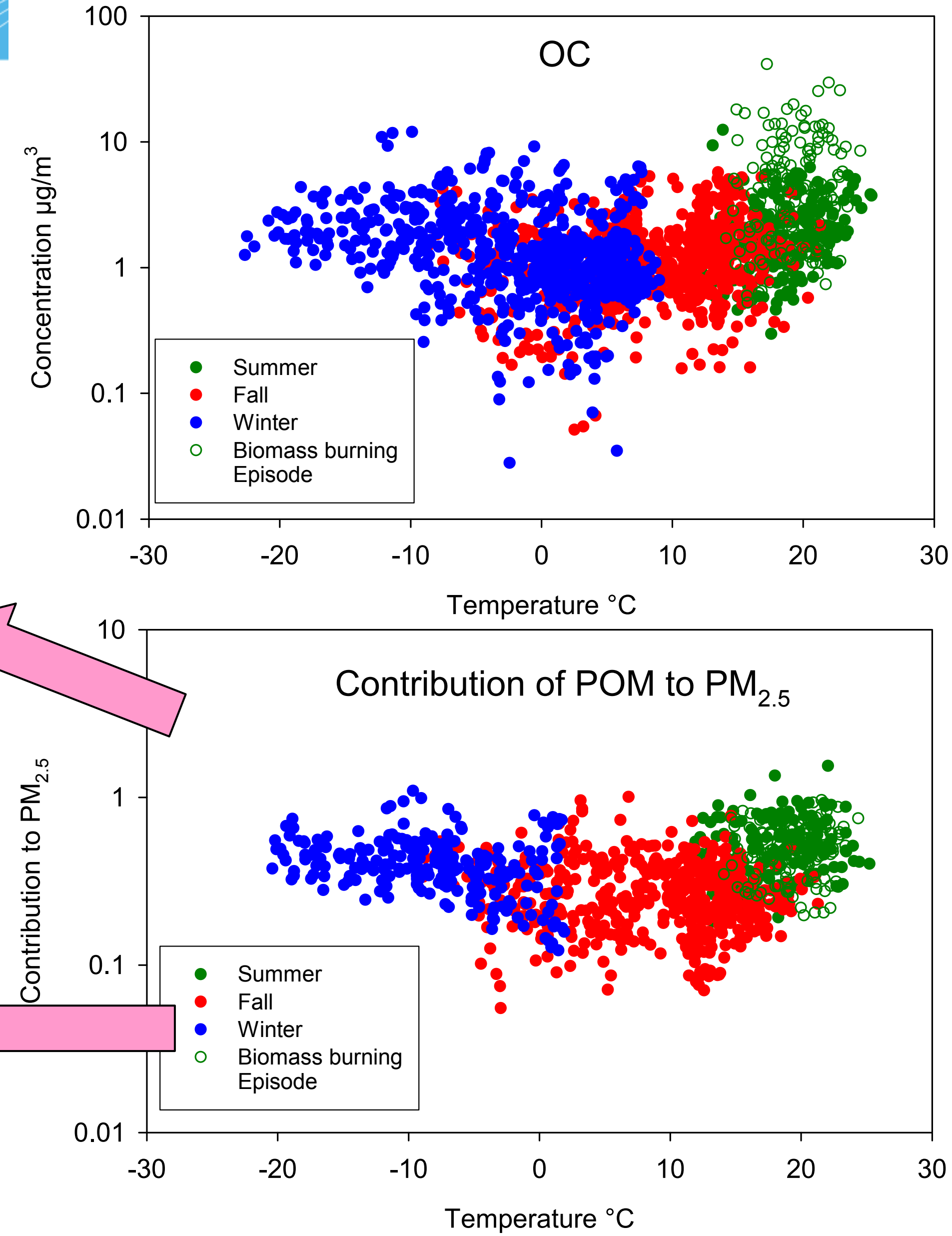
Levoglucosan better qualitative tracer than K^+

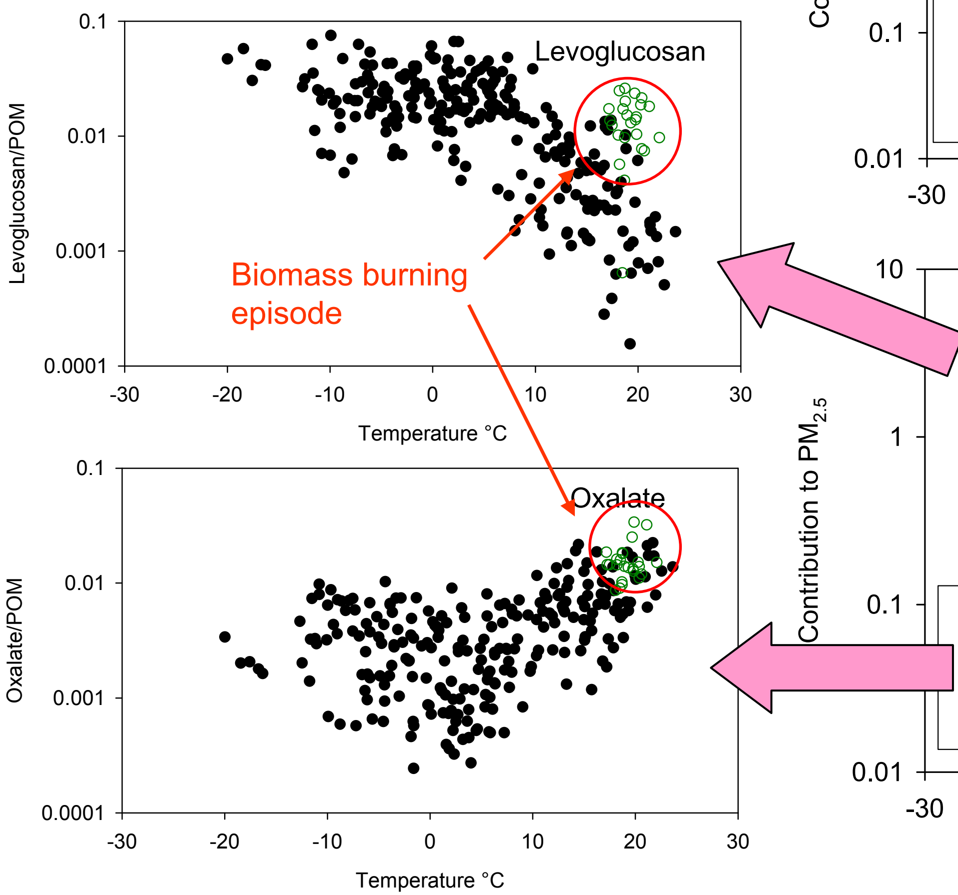
Long-term measurements: two sites

- **PM_1 filter sampling (Feb 07-Feb 08)**



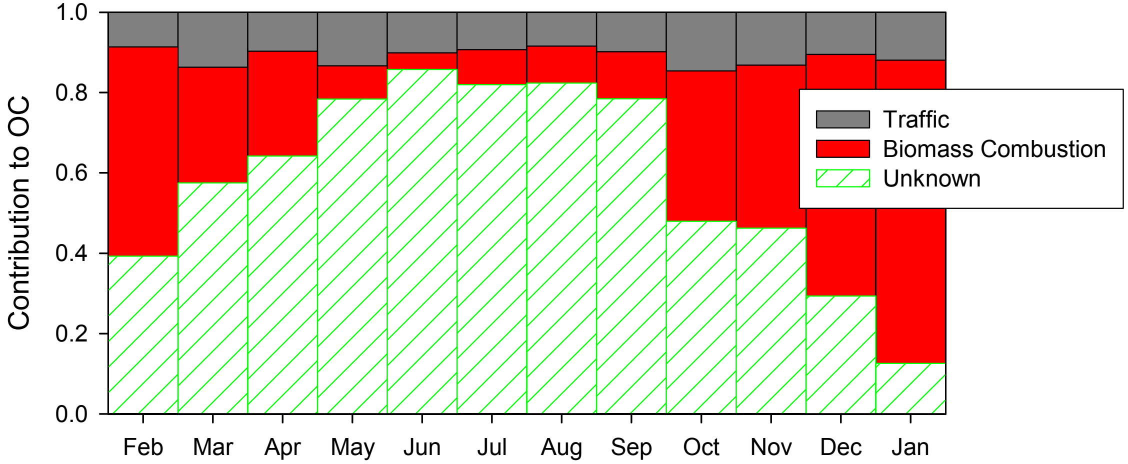
Seasonal variation in Helsinki: Organic carbon

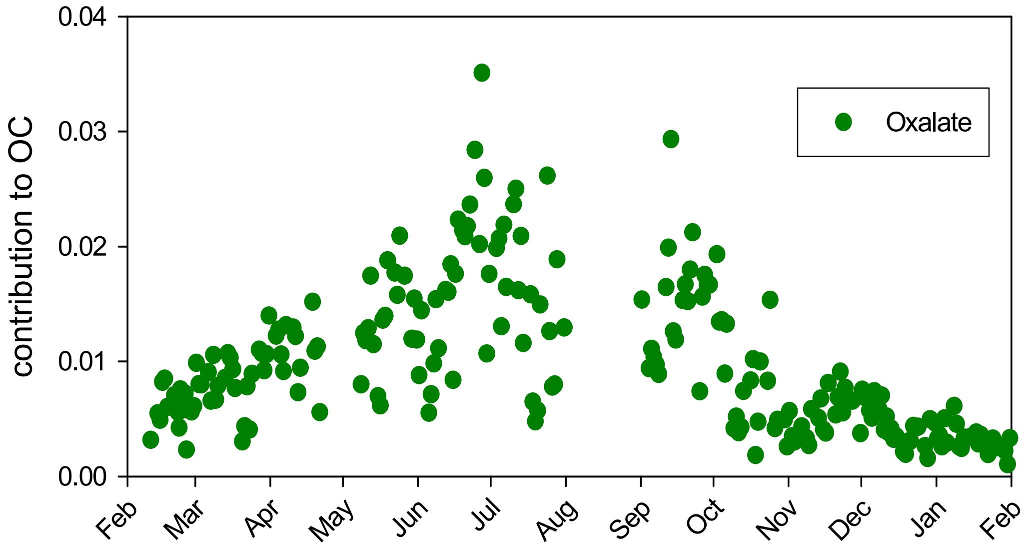




PM_1 organic carbon in Helsinki

-Traffic (primary) based on EC/OC ratio
-Biomass combustion based on levoglucosan to OC ratio
- Unknown is obviously SOA





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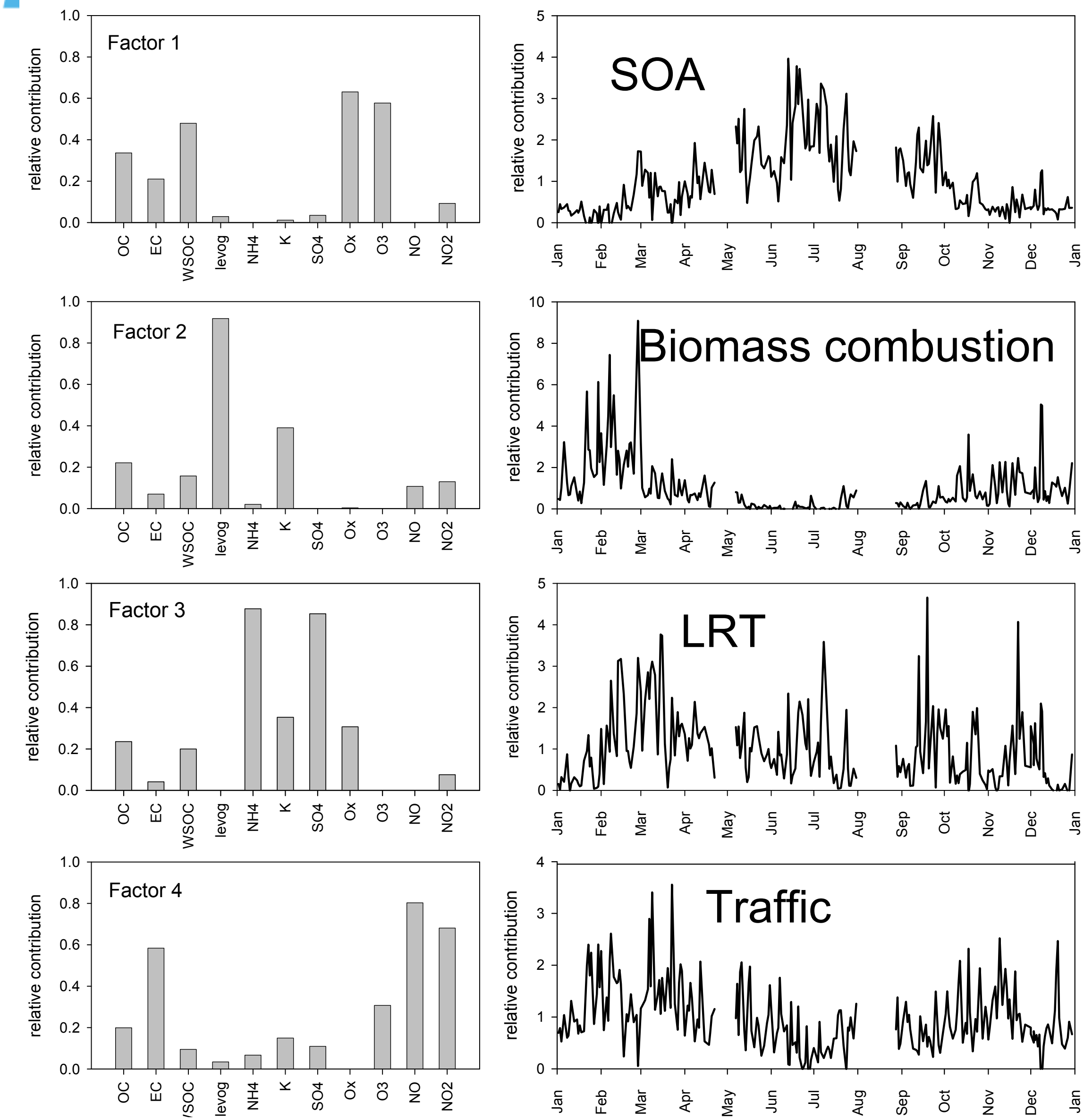
Sources of PM_1 (PMF)

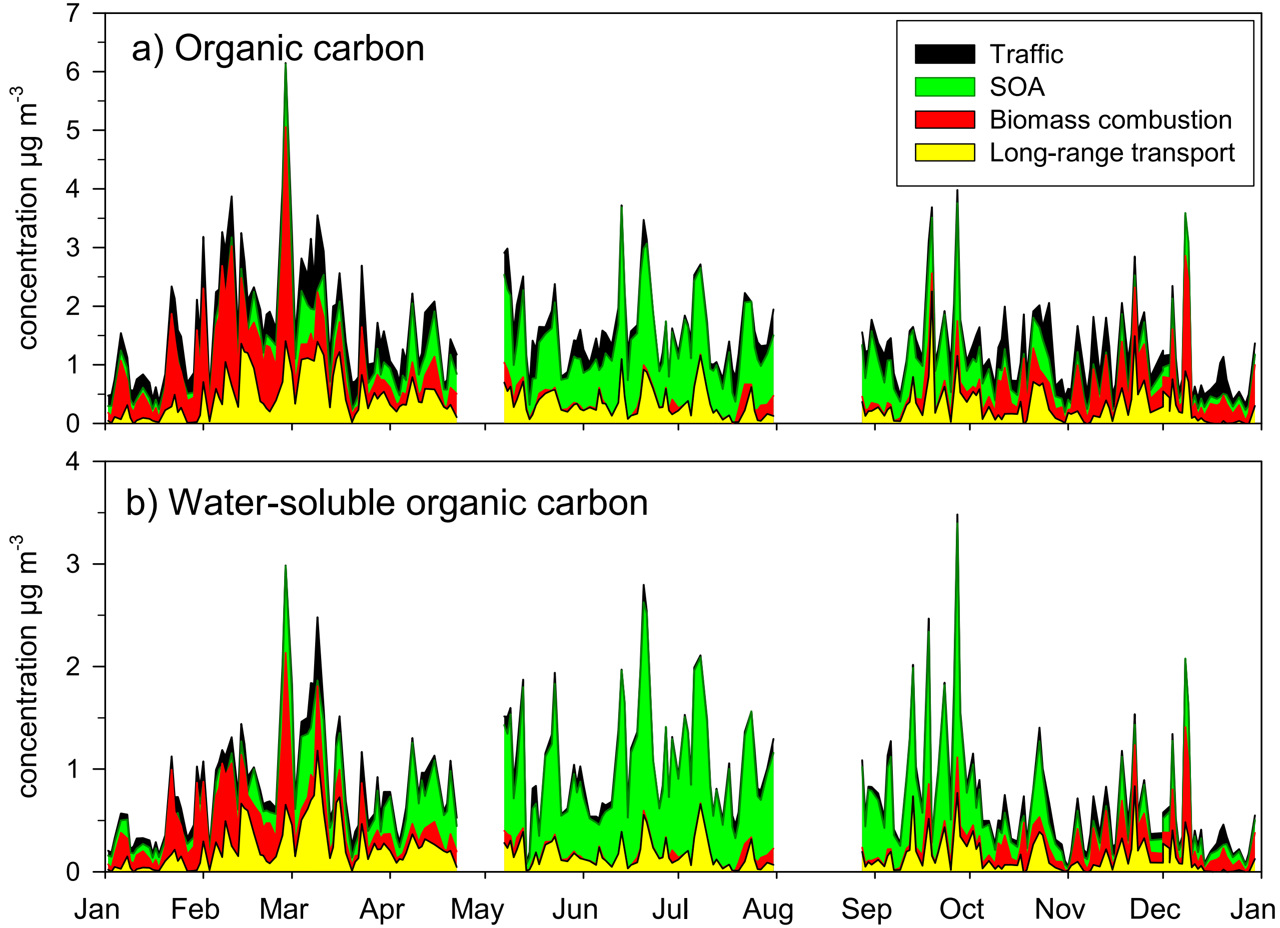


Saarikoski S. et al., 2008, Atmospheric Chemistry and Physics, submitted

Concentrations from different sources

- PM_1 (<1µm)

- **24 h sampling**, chemical analysis in laboratory



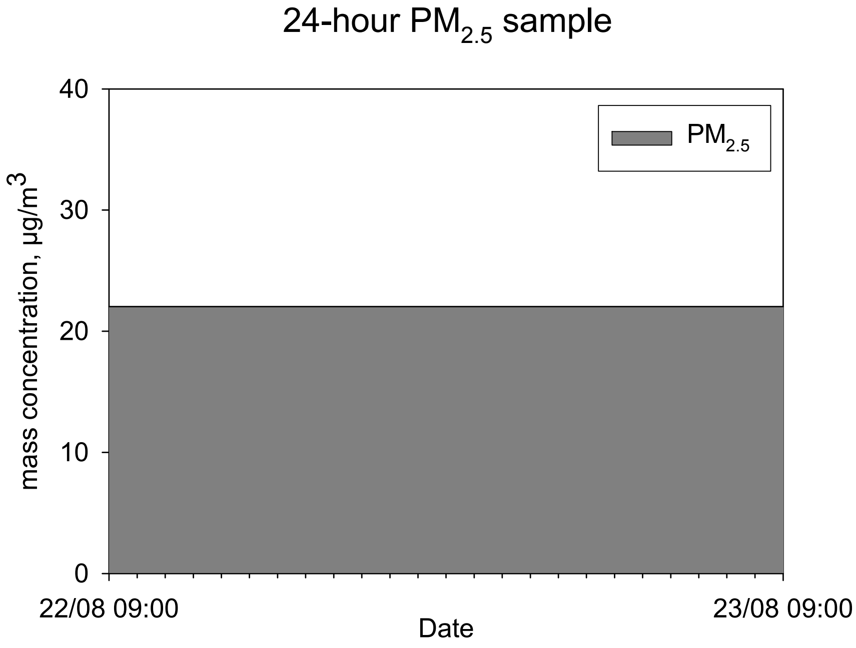
Seasonal source contributions in Helsinki

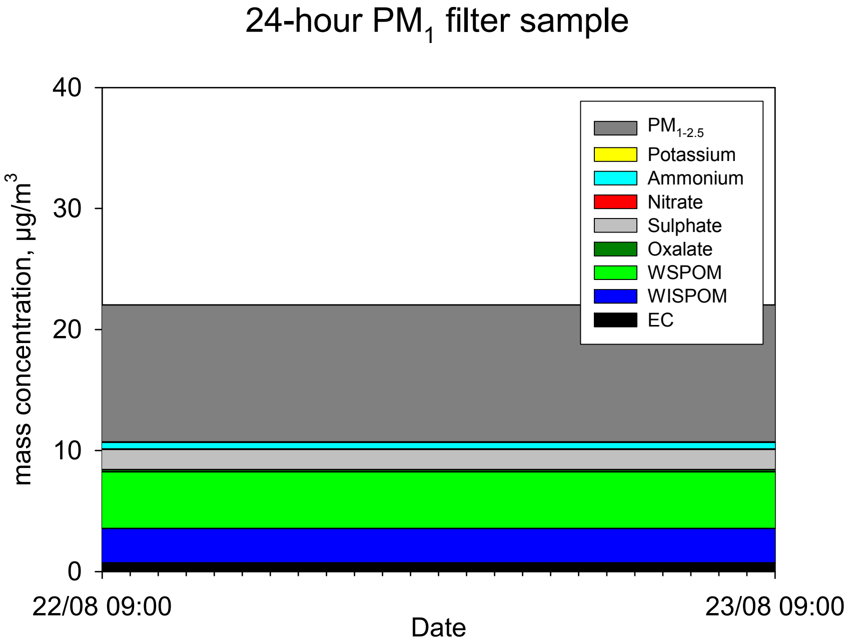
		Winter	Spring	Summer	Fall
% of OC	Secondary organic aerosol	16 ± 11	34 ± 17	**64 ± 12**	32 ± 18
	Biomass combustion	**41 ± 15**	12 ± 8.9	3.4 ± 6.0	20 ± 14
	Long-range transport	17 ± 13	29 ± 10	19 ± 11	21 ± 14
	Traffic	26 ± 12	25 ± 13	15 ± 13	27 ± 15
% of WSOC	Secondary organic aerosol	28 ± 18	49 ± 19	78 ± 8.8	47 ± 21
	Biomass combustion	38 ± 16	11 ± 8.1	2.3 ± 4.1	18 ± 15
	Long-range transport	18 ± 14	27 ± 11	13 ± 8.4	20 ± 13
	Traffic	16 ± 8.5	14 ± 9.0	6.6 ± 6.7	15 ± 11

The source contributions for OC and WSOC in winter (Dec–Feb), spring (Mar–May), summer (Jun–Aug) and fall (Sep–Nov) (average ±SD). Sources and their contributions were identified by PMF.

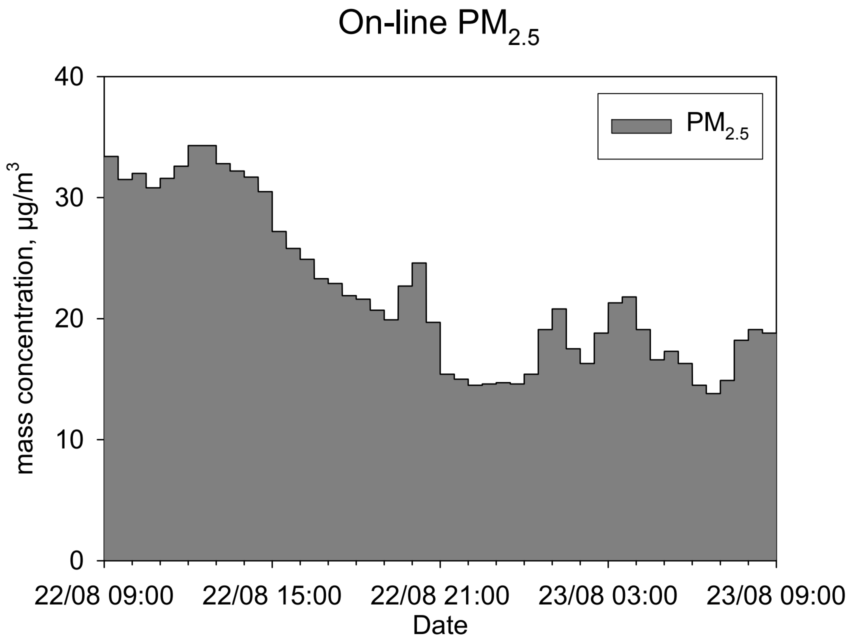
Saarikoski S. et al., 2008, Atmospheric Chemistry and Physics, submitted

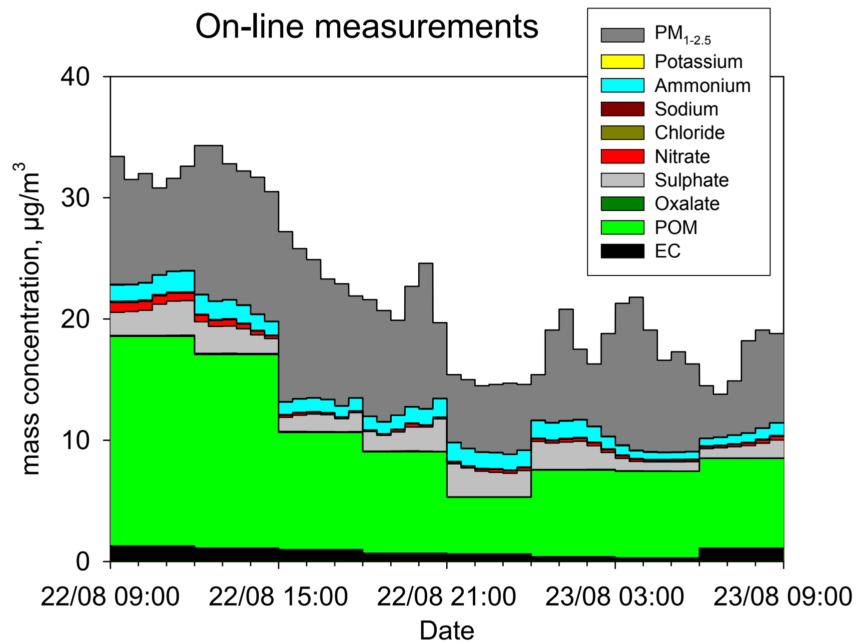
24-hour sample





On-line measurement





Conclusions

- To assess **PM sources,** a large array of chemical components and physical parameters should be measured on long-term basis
- **Atmospheric particulate matter system highly unlinear** → decreasing one component may increase concentrations of other components
- Data from **advanced PM measurements** (in a few locations in Europe) is needed in planning the cost-effective abatement strategy for Europe (health effects or climate change concerns)
- **New challenges for the PM studies** due to combustion of biofuels and other efforts needed to reduce CO_2 emissions