Atmos. Chem. Phys. Discuss., 15, C8030–C8042, 2015
www.atmos-chem-phys-discuss.net/15/C8030/2015/

Atmospheric Chemistry and Physics Discussions

ACPD

15, C8030–C8042, 2015

Interactive Comment

Interactive comment on "Sources of long-lived atmospheric VOCs at the rural boreal forest site, SMEAR II" *by* J. Patokoski et al.

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Received and published: 14 October 2015

Our answers are on the supplementary file and modified and added Figures and Tables are inserted below.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/15/C8030/2015/acpd-15-C8030-2015-supplement.pdf

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 14593, 2015.

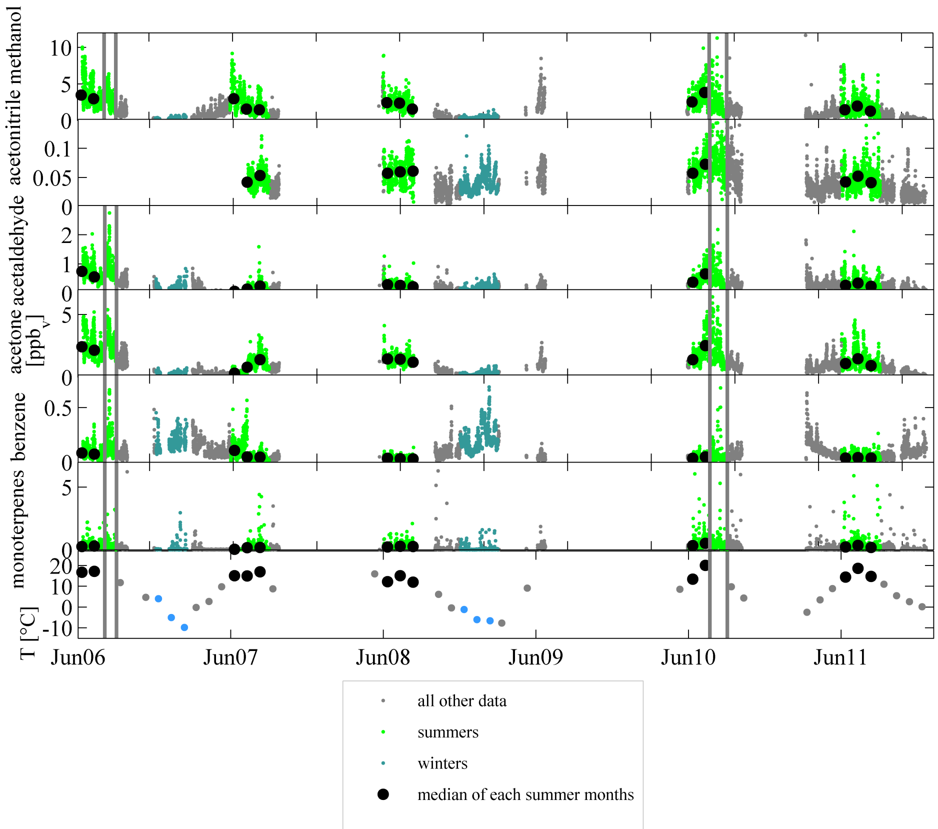

Fig. 1. Figure 1

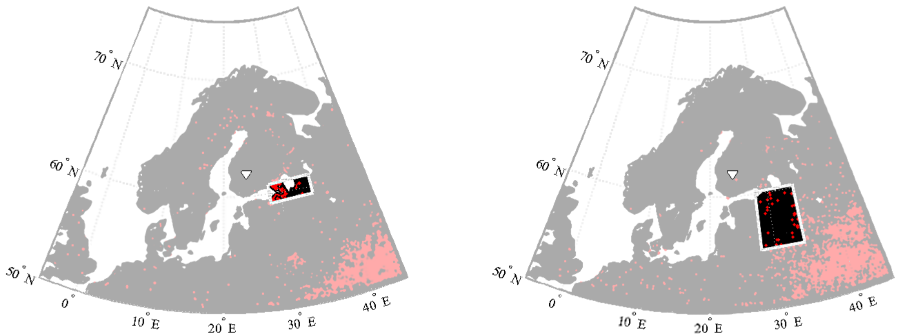

Fig. 2. Figure 2

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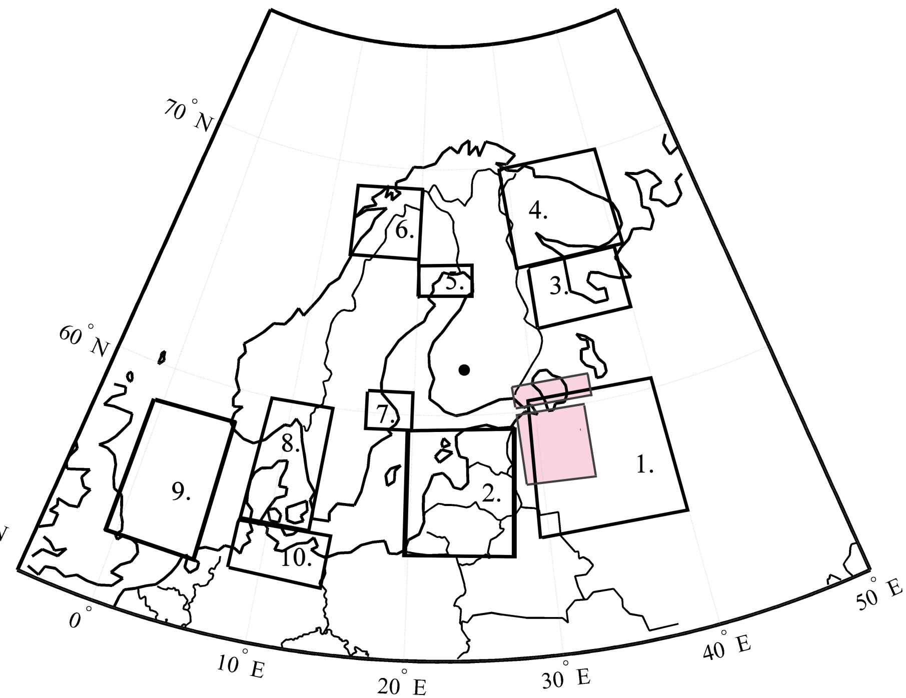

Fig. 3. Figure 6

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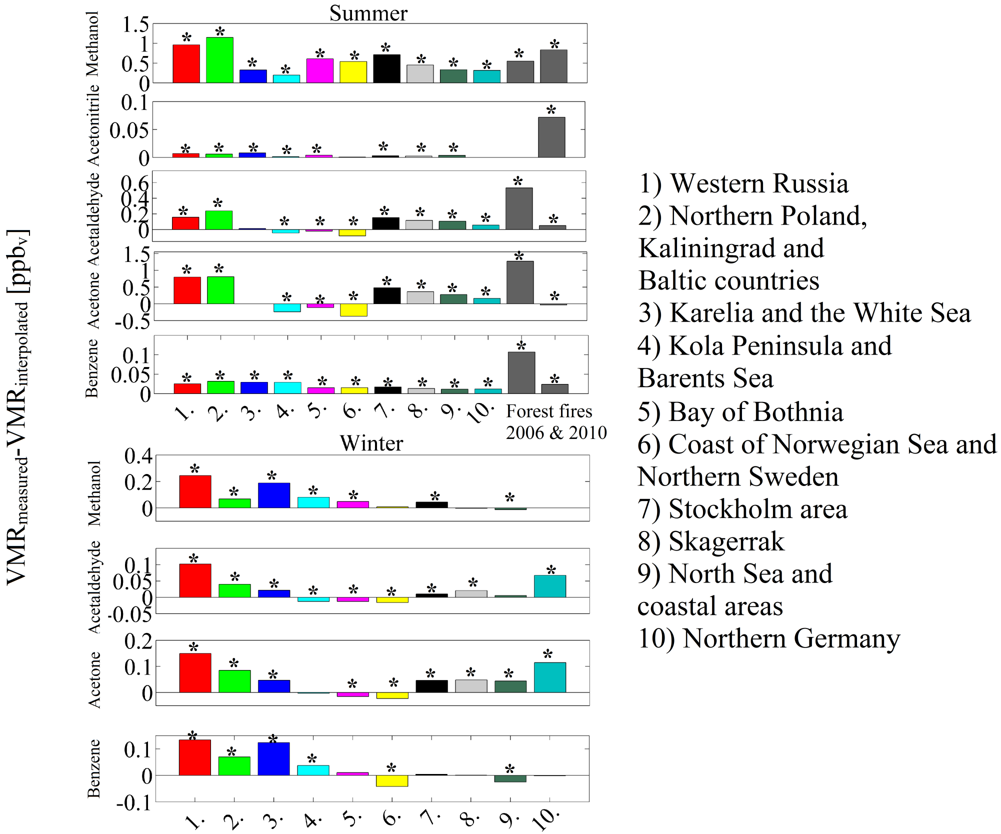

Fig. 4. Figure 7

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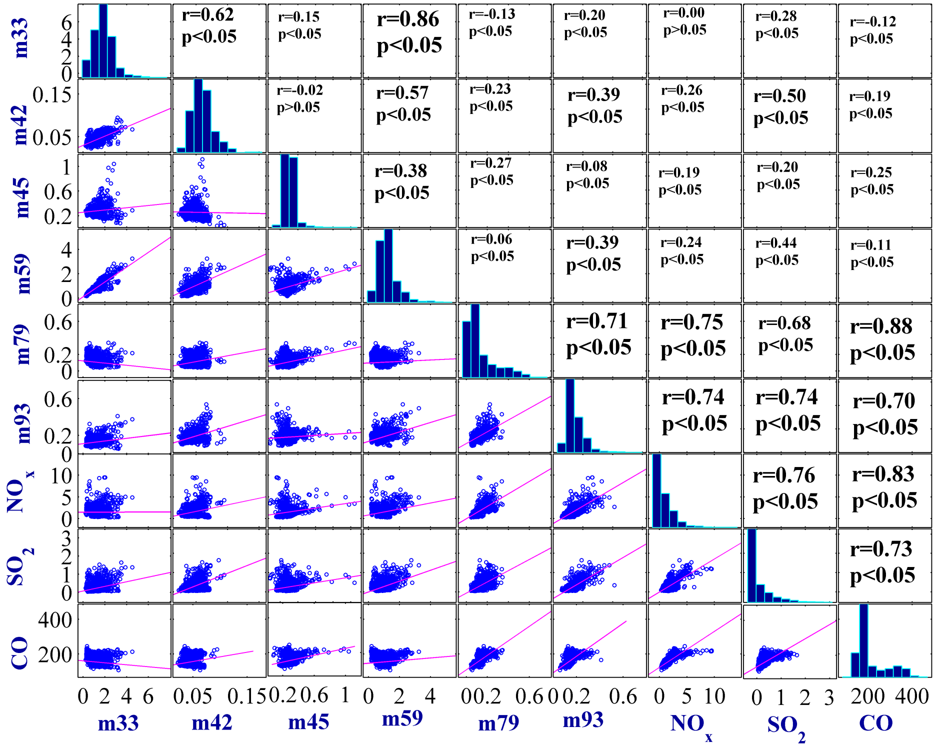

Fig. 5. Figure A1

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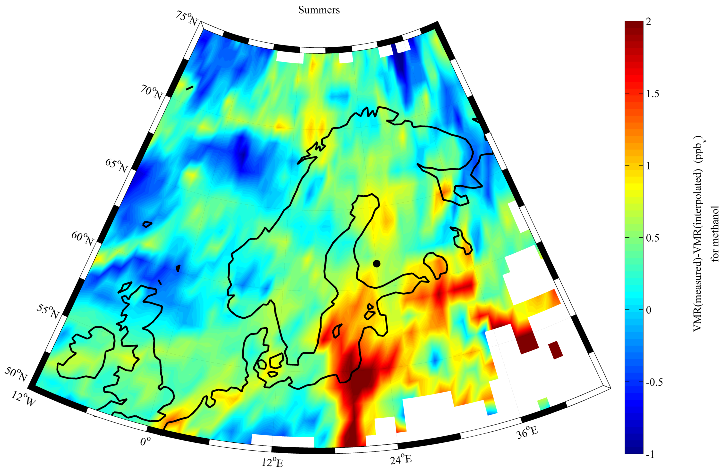

Fig. 6. Figure S1

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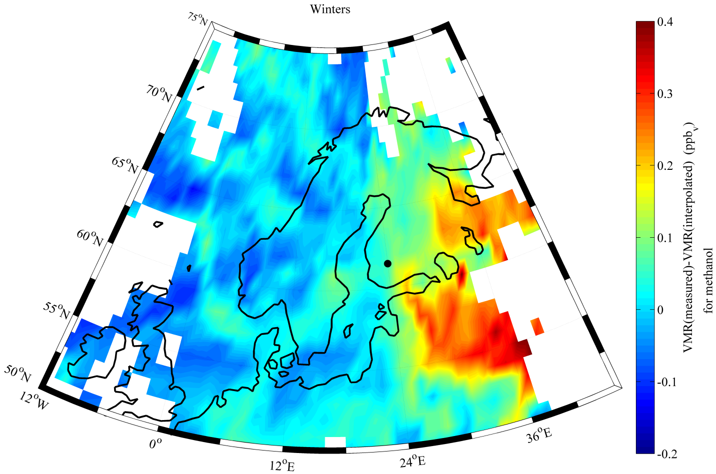

Fig. 7. Figure S2

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Table 2. Concentrations of hydroxyl (OH), ozone (O_3), and nitrate radicals (NO_3) used in the lifetime calculations of the VOCs.

Oxidants	winter [molecules cm^{-3}]	summer [molecules cm^{-3}]
[OH] day	5.5×10^4 [a]	1.5×10^6 [a]
[O_3] day/night	6.8×10^{11}/5.7×10^{11}	8.6×10^{11}/7.1×10^{11}
[NO_3] night	1.2×10^7 [a][b]	4.2×10^7 [a][b]

[a] Hakola et al. (2003). [b] rescaled based on Hakola et al. (2003).

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Fig. 8. Table2

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Table 3. Reaction rate coefficients (k_{OH}, k_{O_3}, k_{NO_3}) and photolysis rates for the measured VOCs.

	k_{OH} [cm^3 molecules^{-1} s^{-1}]	k_{O_3} [cm^3 molecules^{-1} s^{-1}]	k_{NO_3} [cm^3 molecules^{-1} s^{-1}]	$k_{photolysis}$ in winter [s^{-1}]	$k_{photolysis}$ in summer [s^{-1}]
methanol	9.00×10^{-13} [a]		2.42×10^{-16} [d]		
acetaldehyde	1.50×10^{-12} [a]		2.72×10^{-15} [e]	1.50×10^{-6} [f]	3.27×10^{-6} [f]
acetone	1.80×10^{-13} [a]		3.00×10^{-17} [e]	2.32×10^{-7} [f]	4.85×10^{-7} [f]
benzene	1.19×10^{-12} [a]	1.70×10^{-22} [c]	3.00×10^{-17} [d]		
toluene	5.60×10^{-12} [a]	4.10×10^{-22} [c]	6.79×10^{-17} [d]		
monoterpenes	7.50×10^{-11} [b]	1.4×10^{-17} [b]	7.06×10^{-12} [b]		

Rate constants (k_{OH}, k_{O_3} and k_{NO_3}) used in calculations in Table 4: (a) iupac preferred, (b) Monoterpenes' rate constants k_{OH}, k_{O_3} and k_{NO_3} were calculated as weighted averages of individual monoterpenes typical in SMEAR II (Hakola et al., 2003), individual k values (Atkinson, 1994), (c) Atkinson, 1994, (d) http://kinetics.nist.gov/kinetics/Search.jsp, last access: 17 January 2013, (e) Rinne et al. (2007), (f) Calculated similar to Hellén et al. (2004).

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Fig. 9. Table3

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Table 4. Total atmospheric lifetimes (e-folding times) of the VOCs studied, daytime and night-time in summer and winter. Daytime values are the sums of lifetimes calculated towards O_3, OH and photolysis. Night-time values were calculated towards O_3 and NO_3.

VOC	total lifetimes on a winter day	total lifetimes on a winter night	total lifetimes on a summer day	total lifetimes on a summer night
methanol	~~234~~ 230 d	1 y	9 d	~~113~~ 110 d
acetonitrile	29 y	5300 y	1 y	1500 y
acetaldehyde	~~7~~ 5 d	1 y	~~2~~ 1 d	~~101~~ 100 d
acetone	48 d	88 y	15 d	25 y
benzene	~~177~~ 180 d	69 y	6 d	27 y
toluene	38 d	29 y	1 d	11 y
monoterpenes	1 d	3 h	1 h	0.9 h

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Fig. 10. Table4

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Table 5. Mean VMRs of studied trace gases (ppb_v) and ~~SDs~~ standard deviations (~~std~~SDs) before and during the forest fire episodes in 2006 and 2010. The VMRs of the compounds were calculated from VMR data which were selected using trajectories from the burning areas. Area 1 is [~~27–36~~58–62° ~~E~~N, ~~58–62~~27–36° ~~N~~E] in 2006 and area 2 is [~~28–34~~56–61° ~~E~~N, ~~56–61~~28–34° ~~N~~E] in 2010. Asterisk indicates when VMR of a trace gas differs significantly from pre-fire VMR (two-sided t-test)

Compounds	in 2006 before episode	~~std~~SD	in 2006 during episode	~~std~~SD	in 2010 before episode	~~std~~SD	in 2010 during episode	~~std~~ SD
methanol	~~4.94~~4.9	0.78	~~3.21~~3.2*	1.21	~~3.74~~3.7	0.75	~~3.69~~3.7	2.10
acetonitrile					0.06	0.01	0.13*	0.07
acetaldehyde	0.86	0.31	0.94	0.41	0.55	0.09	0.76*	0.40
acetone	3.0	0.40	3.0	0.88	2.0	0.32	2.8*	1.44
benzene	0.08	0.03	0.17*	0.13	0.05	0.03	0.09*	0.06
toluene	0.05	0.03	0.09*	0.07	0.21	0.09	0.28*	0.11
sulphur dioxide	0.23	0.14	0.16*	0.15	0.20	0.12	0.35*	0.42
Nitrogen oxides	1.3	0.56	1.3	0.51	0.60	0.47	0.47	0.28
carbon monoxide	130	5	150*	49	110	9	150*	45

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Fig. 11. Table5

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Table A1. Main industries of source areas.

Source area	Main industries	Mean population density of area [persons km^{-2}]
1. Western Russia	Oil and gas trade, shipbuilding yards, machine building, heavy machinery, mining, ferrous and nonferrous metallurgy, chemical industry and energy and paper production[1]	55
2. Northern Poland, Kaliningrad and Baltic countries	Machinery and chemical industry: chemicals, petroleum and refining, shipbuilding and coal mining[2], forestry with wood and processed wood products, chemical, pharmaceuticals, plastic and rubber industry, metal and electronics industry[3]	63
3. Karelia and White Sea	Forest industry, ferrous and non-ferrous metallurgy, coastal areas of the White Sea: oil production and processing[4]	3
4. Kola Peninsula and Barents Sea	Mining, iron industry (iron-ore enterprises and separators), apatite production and other metal industry such as aluminum and nickel plants and smelters[5], petroleum industry[6]	5
5. Bay of Bothnia	Metallurgy and wood and timber industry[7]	15
6. Coast of Norwegian Sea and Northern Sweden	Machinery, metal industry and mining [7,8]	3
7. Stockholm area	Electronics and chemical industry, machinery[7]	48
8. Skagerrak	Machinery, metallurgy and chemical industry[7]	117
9. North Sea and coastal areas	Oil production[9]	358
10. Northern Germany	Chemicals, plastics, electronics and automotive industry[10], dockyards for shipbuilding, metal industry and machinery[11]	203

[1] Ria Novosti (2010); World Factbook (2014a); [2] World Factbook (2014b); [3] Industries (2014c); [4] Artic Centre (2005); [5] Hansen and Tønnessen (1998); [6] Austvik (2007); [7] Internship to industry (2009); [8] Bothnian green logistics corridor (2012); [9] EIA (2014); [10] GTAI (2013); [11] GTAI (2011).

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Fig. 12. TableA1