Foto: Jörg Sintermann, AWEL

Did policies to abate air pollution have an positive effect on Black Carbon ?

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Motivation and Outline

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Did policies to abate atmospheric emissions from traffic have a positive effect in London?☆

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- ⇨ Trend of Black Carbon (BC) at roadside sites in London (UK)

- – Situation in Switzerland

Font and Fuller (2016)

Policies implemented in London to improve air quality

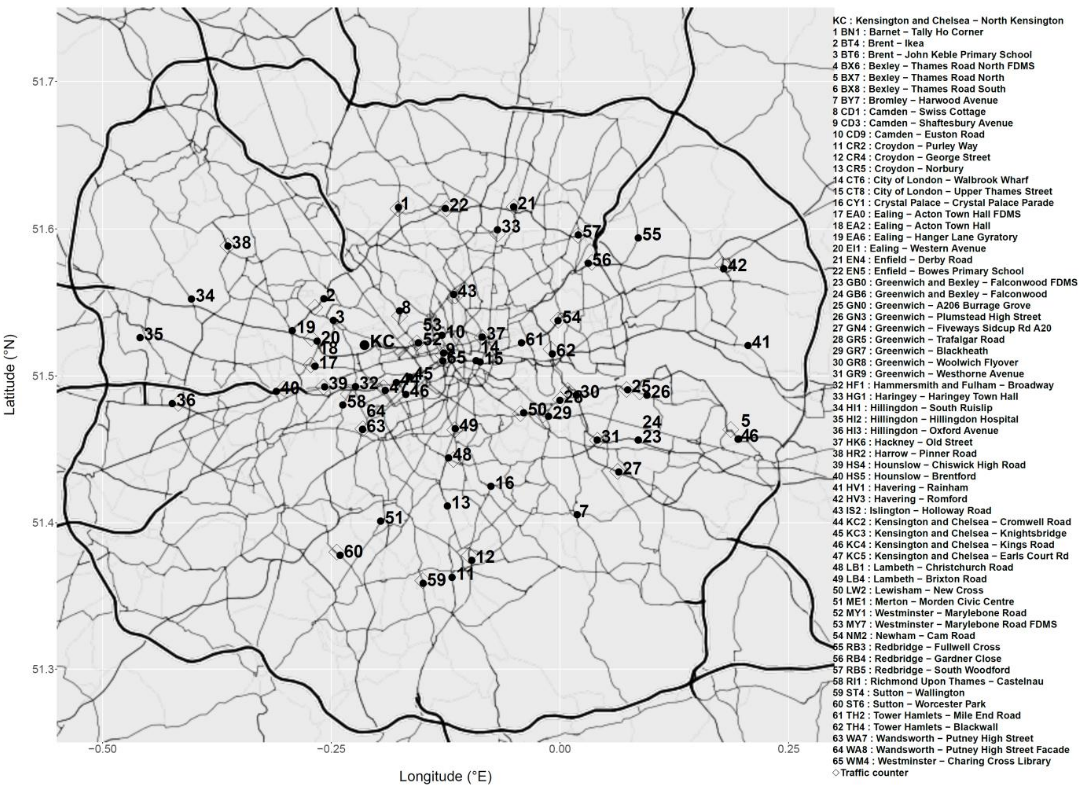
- The Euro emission standards were introduced in the early 1990s to reduce exhaust emissions
- Transport for London (TfL) invested in a program to fit a catalytic diesel particulate filters (CDPF) to its older buses by the end of 2005
- A second bus retrofit campaign with over 1000 Euro III buses fitted with a SCR completed by TfL in 2014. Fitting SCR was prioritized for buses with routes along busy roads in central London
- Other initiatives across London include the Low Emission Zone implemented in 2008 limiting entrance of most polluting diesel Heavy Good Vehicles (HGVs) in London
- The Mayor's Air Quality Strategy in 2010 planned the roll out of new hybrid buses and low-emission buses (Euro IV) (GLA, 2010)
- All these policies have been accompanied by many local-scale schemes implemented by the London's boroughs

⇨ Impact on air quality in London?

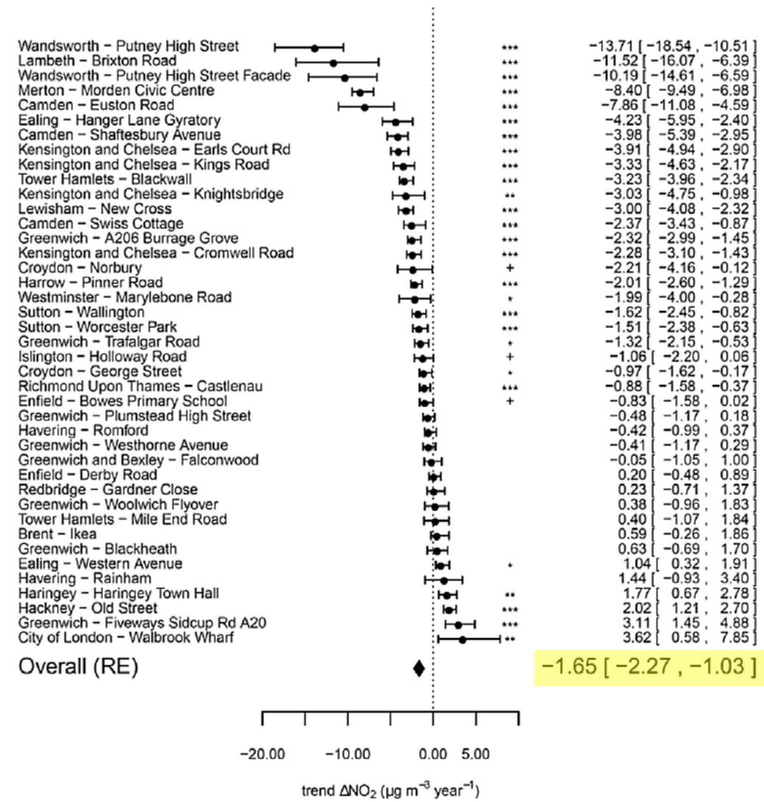
Analysis of data from roadside air quality monitoring sites in London

Trends estimated separately for two time periods: 2005-2009 and 2010-2014

Map of roadside air quality monitoring sites in London



Trend ΔNO_2 2010-2014



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Font and Fuller (2016)

Calculated overall and absolute trends for roadside increments (Δ)

Increase reflects overall real world emissions from diesel vehicles

Downward trends! Not fully explained by changing traffic counts ⇒ Success of abatement policies

Pollutant	Overall trend	2005–2009	2010–2014
ΔNO_X	$\mu g\ m^{-3}\ year^{-1}$	0.87 [0.07, 1.68]	−1.11 [−2.27, 0.04]
	$\%\ year^{-1}$	1.02 [0.07, 1.96]	−0.95 [0.04, −1.94]
ΔNO_2	$\mu g\ m^{-3}\ year^{-1}$	1.63 [1.25, 2.01]	−1.65 [−2.27, −1.03]
	$\%\ year^{-1}$	10.56 [8.08, 13.04]	−4.84 [−2.98, −6.69]
ΔPM_{10}	$\mu g\ m^{-3}\ year^{-1}$	−0.19 [−0.34, −0.03]	0.07 [−0.13, 0.27]
	$\%\ year^{-1}$	−3.92 [−0.69, −7.15]	1.11 [−2.06, 4.27]
$\Delta PM_{2.5}$	$\mu g\ m^{-3}\ year^{-1}$	–	−0.70 [−0.97, −0.42]
	$\%\ year^{-1}$	–	−28.34 [−14.65, −42.03]
ΔCO_2	$\mu g\ m^{-3}\ year^{-1}$	–	0.35 [−0.42, 1.11]
	$\%\ year^{-1}$	–	2.93 [−4.00, 9.85]
ΔBC	$\mu g\ m^{-3}\ year^{-1}$	–	−0.59 [−0.96, −0.23]
	$\%\ year^{-1}$	–	−11.30 [−3.44, −19.16]

No significant overall trend in PM10. Increase in coarse particles offsetting decreasing tailpipe emissions?

Trend CO_2 does not match expectations. Increased fleet efficiency and reduced traffic counts (due to reduced road capacity)

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Font and Fuller (2016)

Conclusions

– Strong downward trend of roadside black carbon increment in London (note: results are based on data from only three sites)

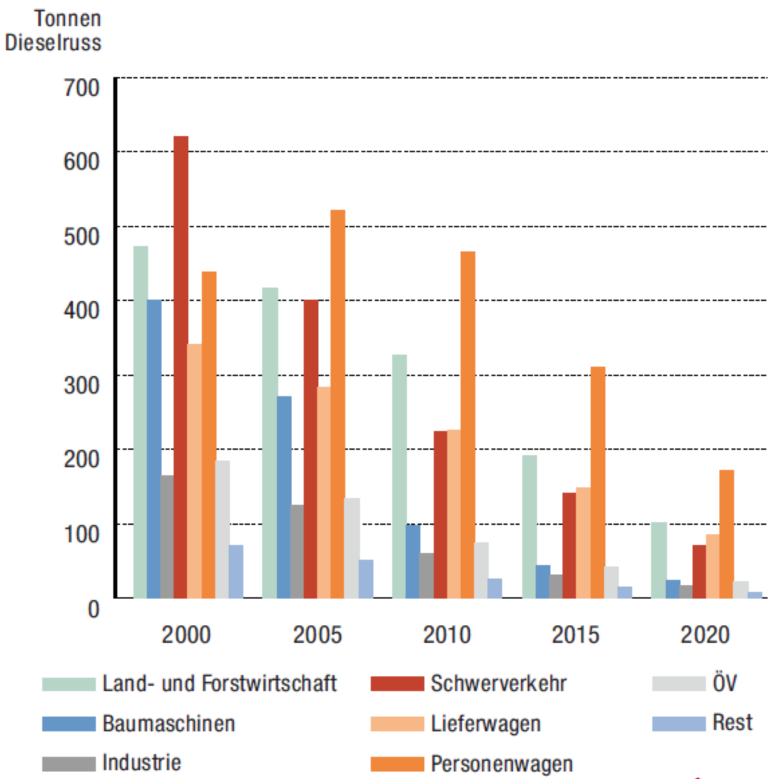
– Roadside black carbon and PM2.5 decreased at similar rates at sites with co-located measurements

– Downward trend of black carbon is attributed to the effectiveness of diesel particle filters

Situation in Switzerland: Implemented policies for abatement of diesel soot (black carbon)

- Implementation of the Euro emission standards (beginning 1995)
- Implementation of policies and programs to fit diesel particulate filters to non-road diesel engines (construction machines, ship engines, cargo trains etc.)
- Heavy vehicle charge (LSVA) for kilometers driven on Swiss roads depends on Euro emission standard
- Financial incentives for low-emission busses
- …

⇨ **Impact on air quality?**



Source: Weniger Russ aus Dieselmotoren, BAFU 2012

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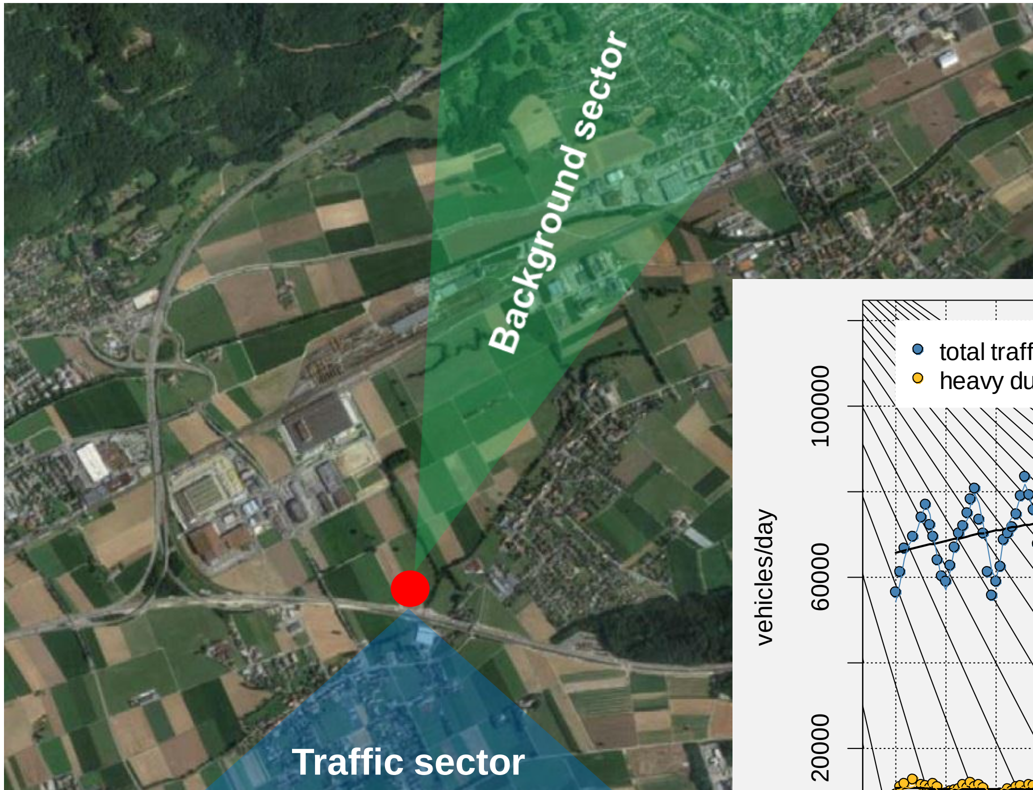
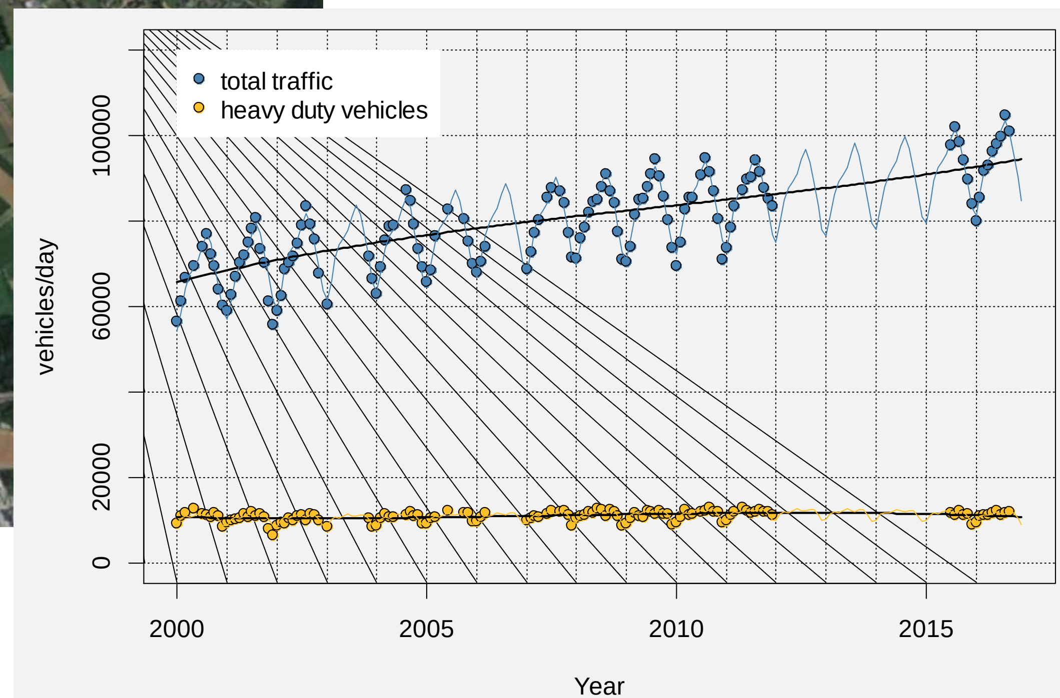
Rural traffic site Haerkingen



- 20m north of highway A1
- traffic increased from 70’000 vehicles/day in 2000 to 95’000 vehicles/day in 2016



⇨ data filtering (wind direction, wind speed, daytime)

⇨ calculation of roadside increments

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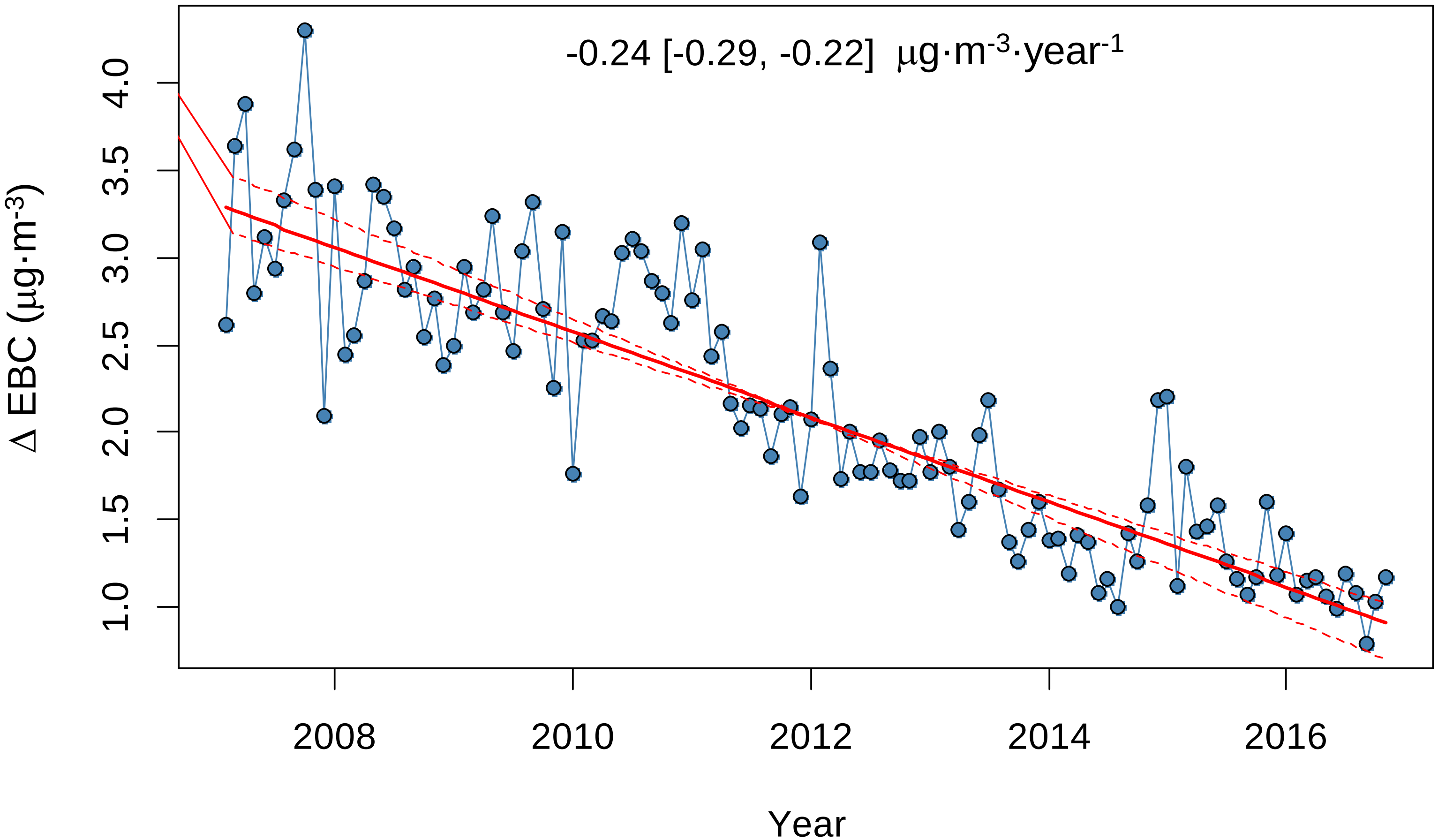
Rural traffic site Haerkingen

calculated trend of equivalent black carbon (EBC) roadside increment



Rural traffic site Haerkingen

calculated trends of roadside increments for **2005 - 2016**

Pollutant	Unit	Trend
Δ NO_x	ppb·m^{-3}·year^{-1}	-2.47 [-3.18, -1.72]
	% year^{-1}	-2.9 [-3.7, -2.0]
Δ NO_2	ppb·m^{-3}·year^{-1}	0.16 [-0.12, 0.38]
	% year^{-1}	0.8 [-0.6, 1.9]
Δ CO	ppb·m^{-3}·year^{-1}	-10.93 [-14.64, -7.64]
	% year^{-1}	-7.3 [-9.8, -5.1]
Δ CO_2	ppm·m^{-3}·year^{-1}	0.19 [-0.81, 0.97]
	% year^{-1}	0.5 [-2.2, 2.6]
Δ PM_{10}	µg·m^{-3}·year^{-1}	-0.19 [-0.35, 0.09]
	% year^{-1}	-6.3 [-11.3, 3.0]
Δ PNC	number cm^{-3}·year^{-1}	-3172 [-4913, -1903]
	% year^{-1}	-7.3 [-11.3, -4.4]
Δ EBC	µg·m^{-3}·year^{-1}	-0.24 [-0.29, 0.21]
	% year^{-1}	-11.6 [-13.5, 10.4]

Strong downward trends!
⇒ Success of abatement policies

Downward trends of NO_x
Change in NO_2 driven by secondary formation
$NO+O_3 = NO_2+O_2$!

No significant trend

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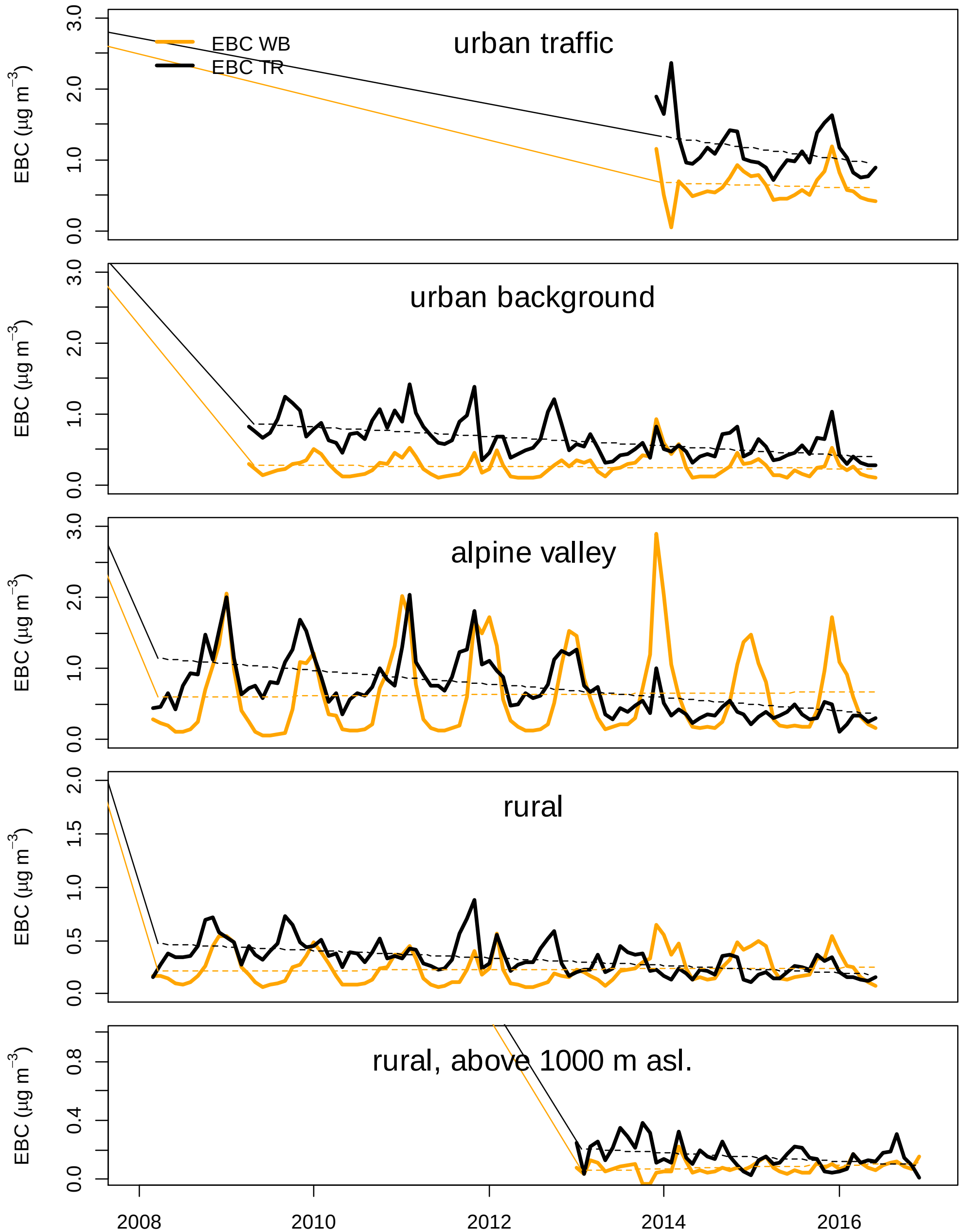
Trend of black carbon from traffic (EBC TR) and wood burning (EBC WB)

For applied method see e.g. Zotter et al. ACPD 2016



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Trends of black carbon (EBC) and black carbon from traffic (EBC_{TR}) and wood burning (EBC_{WB})

Station	Site type	Trend EBC ($\mu g \cdot m^{-3} \cdot y^{-1}$)	Trend EBC_{TR} ($\mu g \cdot m^{-3} \cdot y^{-1}$)	Trend EBC_{WB} ($\mu g \cdot m^{-3} \cdot y^{-1}$)
Bern-Bollwerk	Urban, Traffic	-0.20 (-0.28, -0.12)	*-0.16 (-0.39, 0.04)*[a]	*-0.03 (-0.06, 0.06)*[a]
Härkingen	Rural, Traffic	-0.19 (-0.21, -0.17)		
Zürich-Kaserne	Urban	-0.08 (-0.10, -0.06)	-0.07 (-0.09, -0.05)	-0.01 (-0.01, 0.00)
Lugano-Università	Urban	-0.17 (-0.19, -0.16)		
Dübendorf	Suburban	-0.07 (-0.09, -0.05)		
Basel-Binningen	Suburban	-0.03 (-0.04, -0.02)		
Magadino-Cadenazzo	Rural	-0.08 (-0.15,-0.05)	-0.09 (-0.15, -0.07)	0.01 (0.00, 0.03)
Payerne	Rural	-0.03 (-0.05,-0.02)	-0.04 (-0.05, -0.03)	0.00 (-0.01, 0.02)
Rigi-Seebodenalp	Rural >1000 m asl	*-0.03 (-0.05,-0.01)*[b]	*-0.04 (-0.06, -0.02)*[b]	*0.01 (-0.01, 0.02)*[b]

[a] *based on data from 2½ years*
[b] *based on data from 3½ years*

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Conclusions – Trends in Switzerland

- In agreement to the study for London (Font and Fuller, 2016), roadside increment of black carbon is strongly declining in Switzerland

- Other air pollutants also show significant downward trend of roadside increment at the Haerkingen site (e.g. PNC and NO_x)

- Measurements show that policies for abatement of black carbon emissions from road traffic and other diesel engines were in Switzerland remarkably successful

- In contrast, little progress has been achieved for the reduction of black carbon emissions from wood burning appliances


Foto: Jörg Sintermann, AWEL

Thank you!