Measurements of nitrated aromatic compounds in aerosol particles and their contribution to the light absorption of brown carbon

M. Teich[1], D. van Pinxteren[1], M. Wang[2], S. Kecorius[1], Z. Wang[1,5], T. Müller[1], G. Močnik[3,4], H. Herrmann[1]

[1]Leibniz Institute for Tropospheric Research (TROPOS), Leipzig, Germany
[2]McMaster University, Hamilton, Canada
[3]Aerosol d.o.o., Ljubljana, Slovenia
[4]Condensed Physics Department, Jožef Stefan Institute, Ljubljana, Slovenia
[5]Now at: Multiphase Chemistry Department, Max Planck Institute for Chemistry, Mainz, Germany

✉ teich@tropos.de

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Motivation

Brown Carbon (BrC): Light absorbing organic carbon (300 – 500 nm)

(Andreae und Gelencser 2006, Atmos. Chem. Phys.)

- Contribution of BrC can be very high in regions strongly influenced by biomass burning *(Feng et al. 2013, Atmos. Chem. Phys.)*
- Impact on radiative forcing as well as atmospheric chemistry, e.g. as photosensitizers

  (*Laskin et al. 2015, Chem. Rev.)*

filtered cloud water from Mt. Tai

- ➢ Important to focus on opticial properties and molecular composition
- ➢ Little is known about the molecular composition of BrC and the contribution of individual compounds to the total BrC light absorption

Foto: Desyaterik et al. 2013 , J. Geophys. Res.

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Aims of the study + target compounds

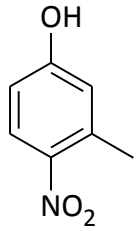
Aims of the study

- Calculation of the fraction of the individual compounds on the total water soluble and particulate BrC light absorption
- Quantitative determination of eight nitroaromatic compounds that may contribute to BrC in field samples (PM_{10}) from several sampling sites seasons

Target compounds

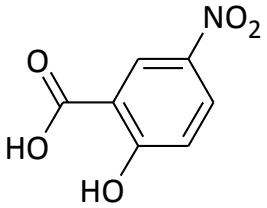
- Focus on nitrophenols and nitrosalicylic acids
- Known to absorb light in near UV – visible range (e.g., Alif et al. 1987, Chemosphere)
- Quantified at many different locations in Europe *(Harrison et al. 2005, Atmos. Environ.)*

Example for nitrophenols:



3-Methyl-4-nitrophenol

Example for nitrosalicylic acids:



5-Nitrosalicylic acid

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Measurement campaigns

Germany

Leipzig, winter 2014

Fichtelgebirge, summer 2014

Melpitz, winter + summer 2014:

China

Xianghe, summer 2013

Wangdu, summer 2014

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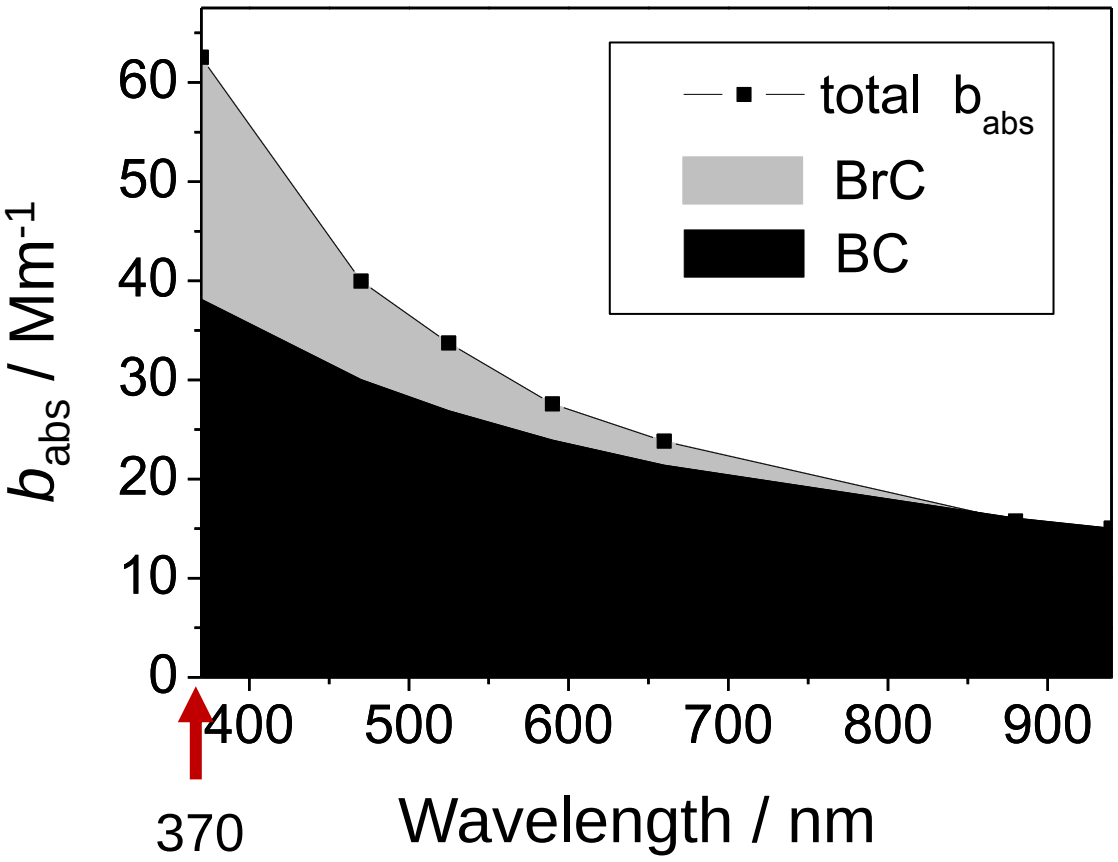
Light absorption measurements: Aethalometer



$$b_{abs} = k \cdot \lambda^{-AAE}$$

Assumptions:

- BC is the only light absorbing species at 940 nm
- AAE of BC is 1.0

b_{abs} - Particulate light absorption coefficient
AAE - Absorption Angström Exponent
BC - Black Carbon

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Light absorption measurements: UV-Vis Spectroscopy

$$\mathrm{Abs}_{370}[Mm^{-1}] = (A_{370} - A_{800})\frac{V_l}{V_a \cdot l} \cdot ln(10)$$

$$MAE_{370}[m^2 g^{-1}] = \frac{Abs_{370}}{[WSOC]}$$

Abs_{370}	*Aqueous extract light absorption coefficient*
A	*Absorbance*
V_l	*Volume of aqueous extract*
V_a	*Volume of sampled air*
l	*Absorption path length*
MAE	*Mass absorption efficiency*
$WSOC$	*Water soluble organic carbon*

- Measurements at pH = 2 und pH = 10
- Determination of Abs_{370} in Mm^{-1} und MAE_{370} in $m^2\ g^{-1}$ (normalized by WSOC)
- Calculation of relative contribution of individual compounds to WSOC light absorption

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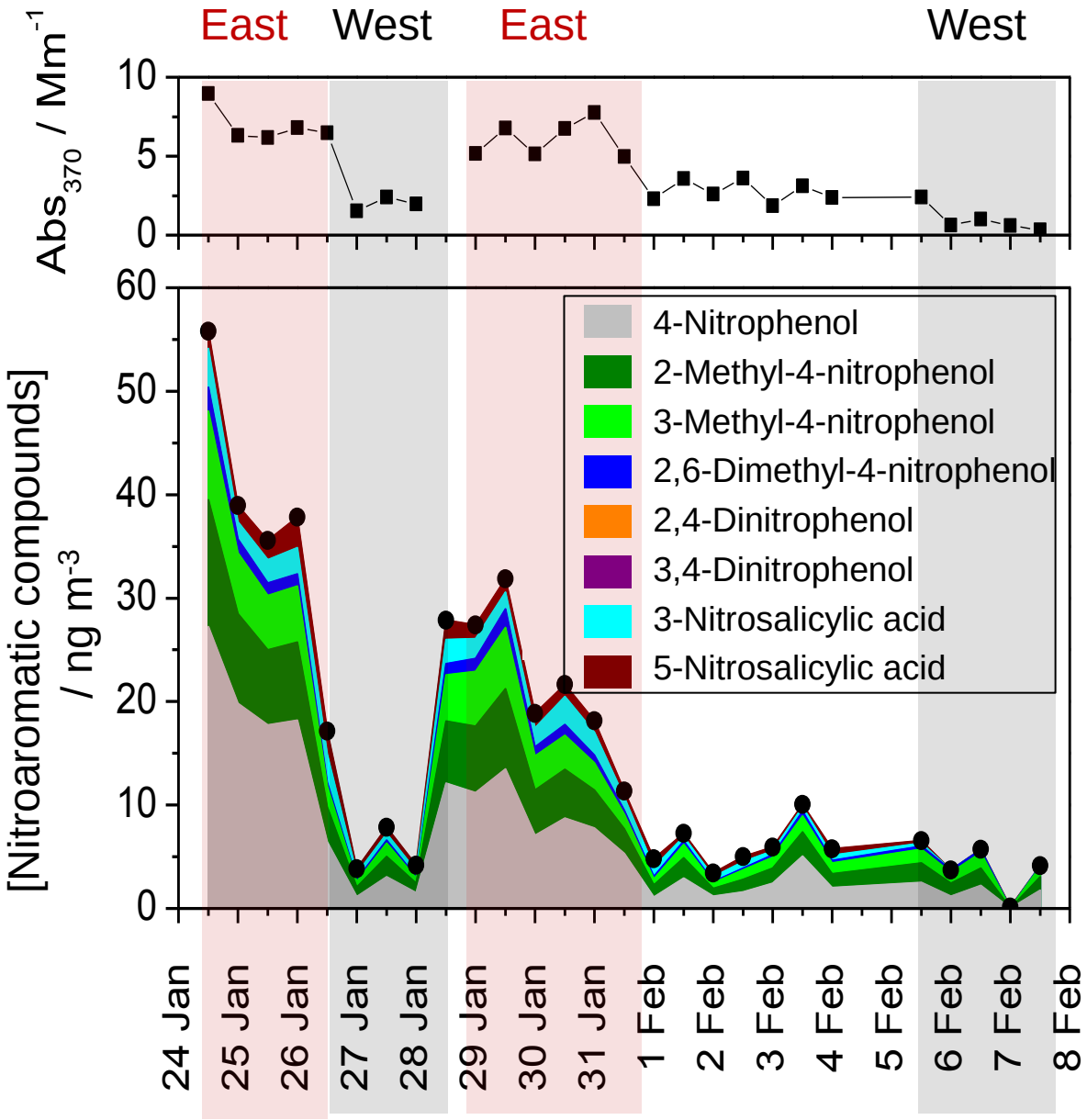
Results: Leipzig, Winter 2014 (I)



Urban background,
Influence of biomass burning aerosol according to Levoglucosan

- **4-Nitrophenol present in highest concentration**
- **Influence of air mass origin on concentration**

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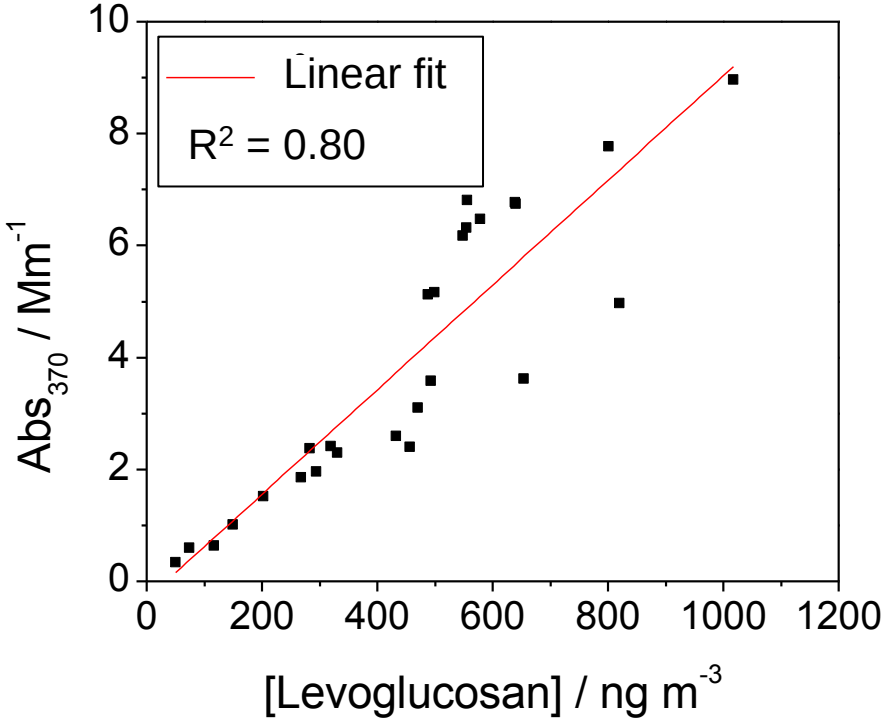
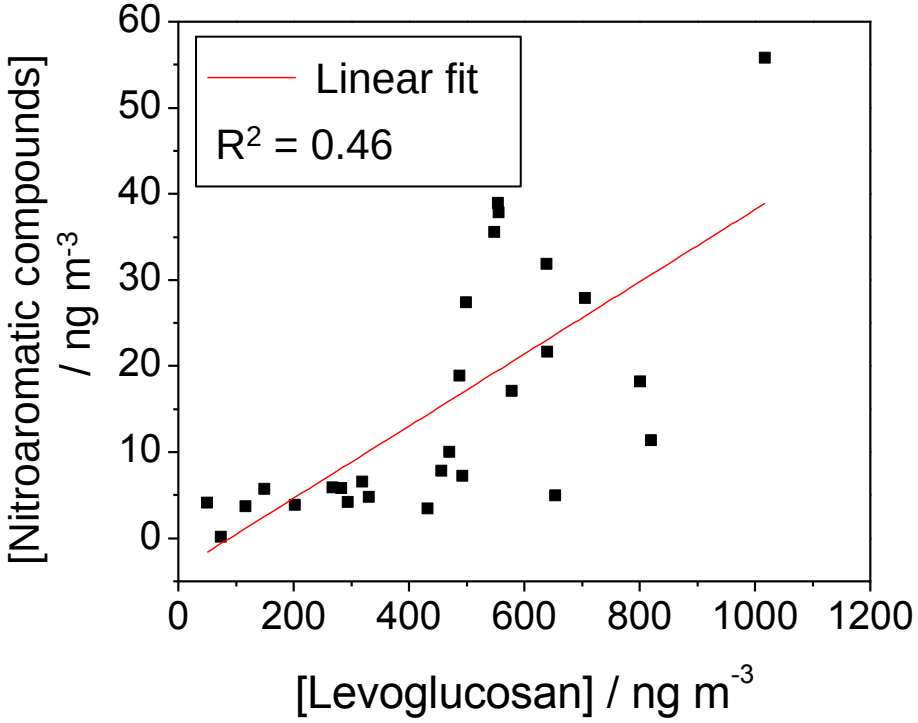
Results: Leipzig, Winter 2014 (II)





- **Indication of influence of biomass burning on the light absorption**
- **Indication of other sources besides biomass burning**

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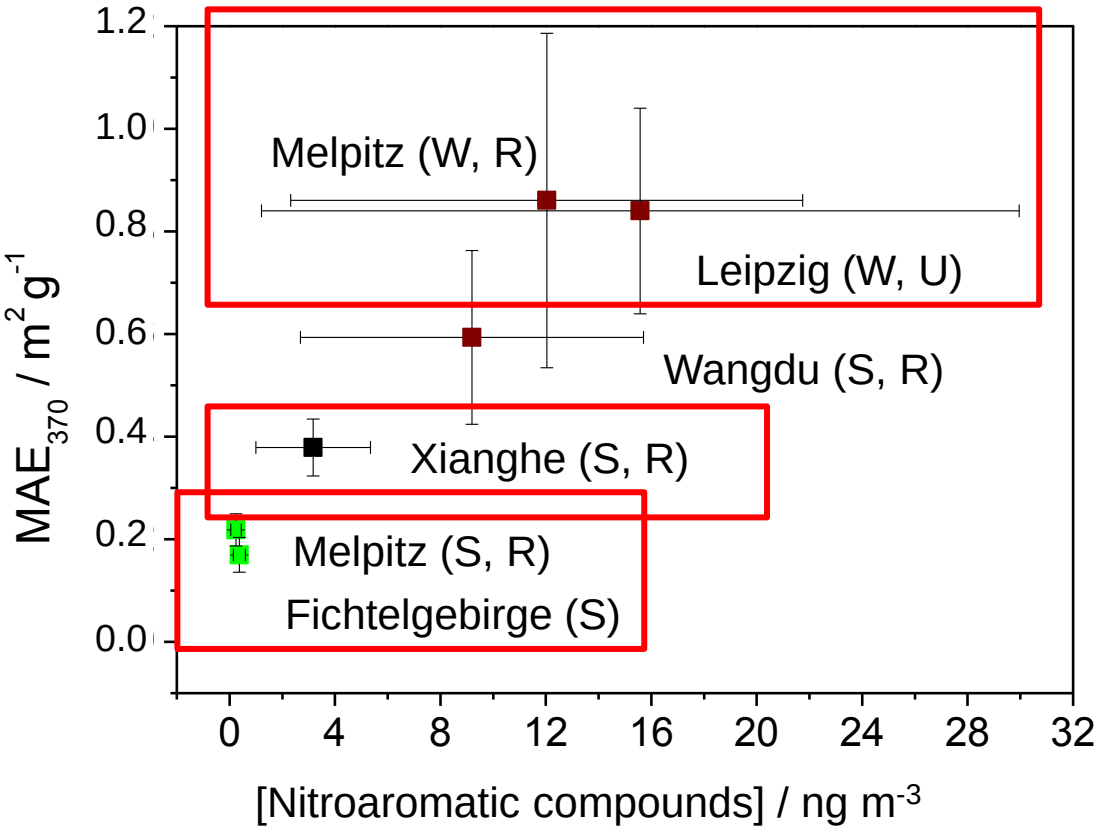
Results: Concentration + optical properties



- **Fresh biogenic aerosols are weakly absorbing**
- **Indication of BrC from anthropogenic secondary aerosol**
- **Light absorption/ concentration higher in winter**

S	*Summer*
W	*Winter*
R	*Rural background*
U	*Urban background*
MAE	*Mass absorption efficiency*

Main influence:

biomass burning, biogenic, anthropogenic

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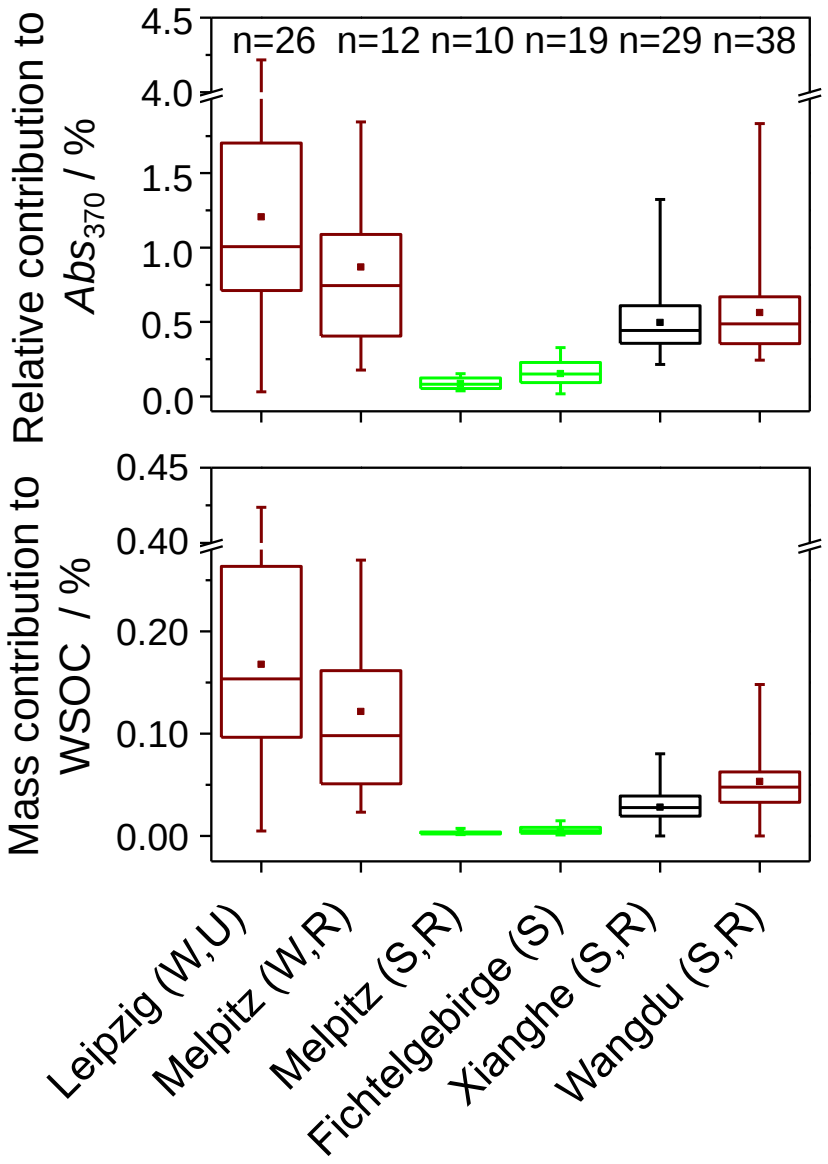
Results: Contribution to light absorption (I)



- **Mean contribution of 1.2 % to Abs_{370} (maximum 4.2 %)**
- **Mean mass contribution of 0.2 % nitroaromatic compounds to WSOC (maximum 0.4 %)**
- **High impact of small amounts of light absorbing compounds**

Main influence: biomass burning, biogenic, anthropogenic

S	*Summer*
W	*Winter*
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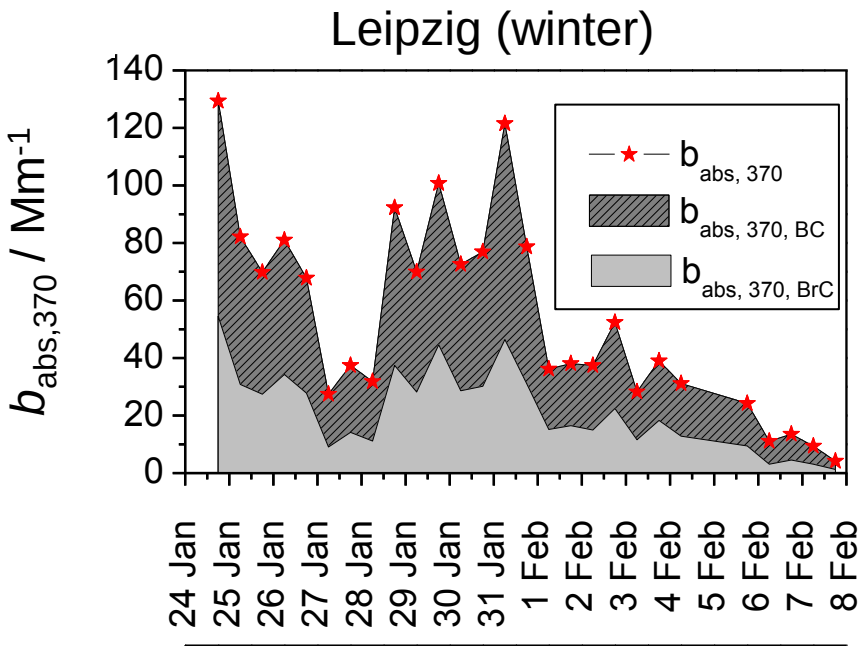
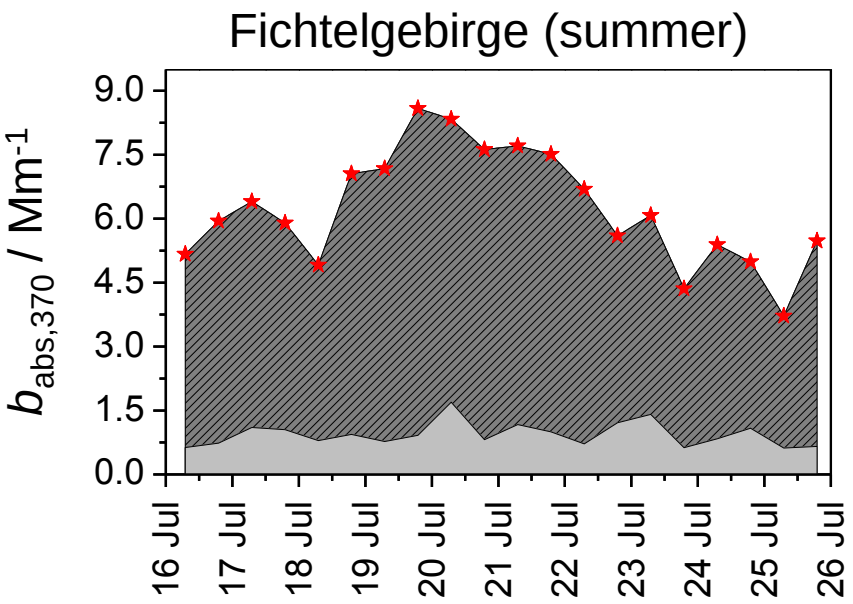
U	*Urban background*

WSOC Water soluble organic carbon

Results: Contribution to light absorption (II)





40 %	Contribution of BrC	15 %
0.25 %	Mean contribution of nitroaromatic compounds to $b_{abs, BrC, 370}$	0.1 %

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Next steps

- Determination of primary emission factors from hard and soft woods and straw
- Source study to gain insides into the chemical processing of nitroaromatic compounds in biomass burning aerosol

Leipziger Biomass Burning Facility, LBBF

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Thank you for your attention!

- *MAE*, *Abs*, b_{abs} and concentrations higher in winter
- Strong relationship between light absorption properties and biomass burning aerosol concentrations
- Freshly emitted biogenic aerosols only weakly absorbing
- High impact of small amounts of light absorbing compounds

Teich et al. 2017, Atmos. Chem. Phys.

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Contributions of nitrated aromatic compounds to the light absorption of water-soluble and particulate brown carbon in different atmospheric environments in Germany and China

Monique Teich[1], Dominik van Pinxteren[1], Michael Wang[2], Simonas Kecorius[1], Zhibin Wang[1,a], Thomas Müller[1], Griša Močnik[3,4], and Hartmut Herrmann[1]

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