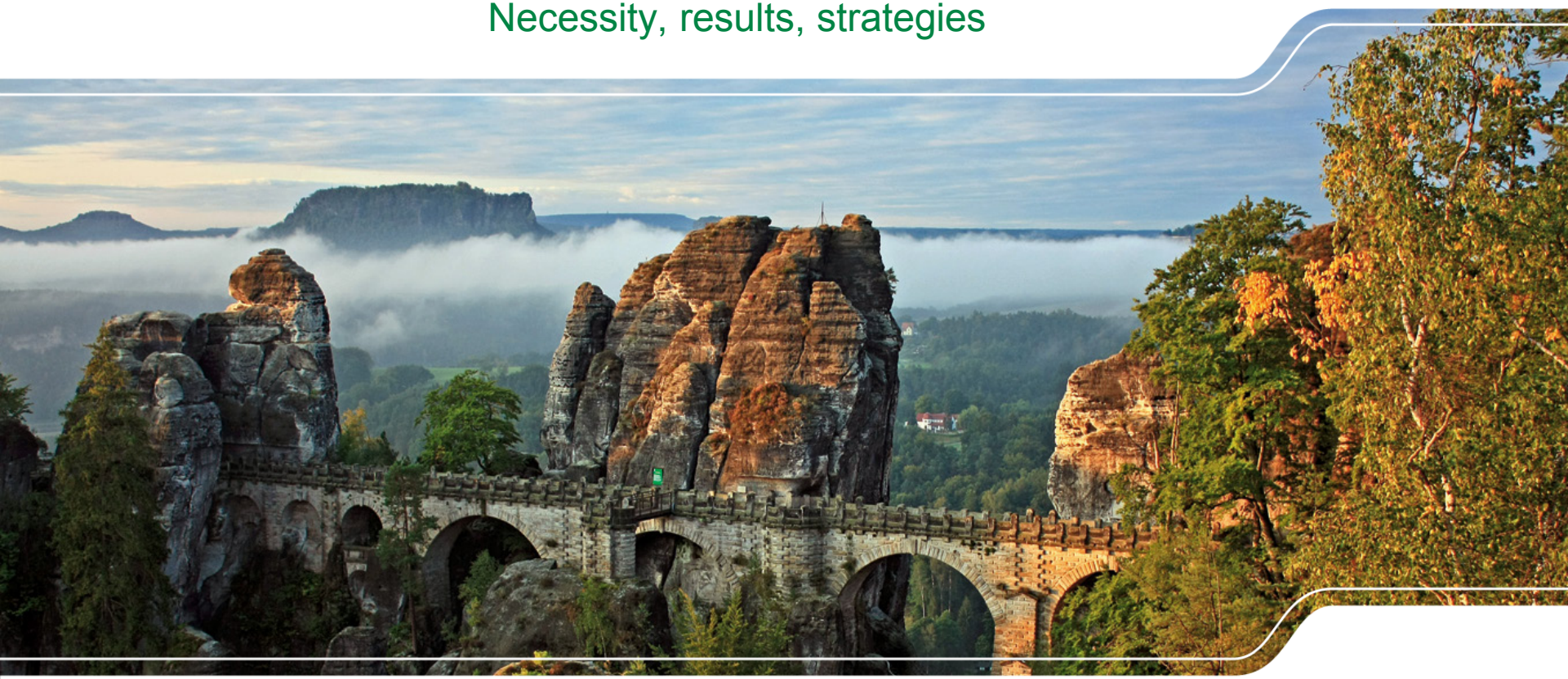
STAATLICHE BETRIEBS-
GESELLSCHAFT FÜR UMWELT
UND LANDWIRTSCHAFT

Freistaat
SACHSEN

Soot measurements in Saxon air monitoring sites with the thermal- optical method and the EUSAAR- II - Programme

Necessity, results, strategies



Overview

- **1.Measurement methods**
- **2.Legal regulations**
- **3. Measurement history Saxon air monitoring network**
- **4. Procedures of other departments for monitoring air quality in Germany**
- **5. The problem of quality assurance**
- **6. The approach of the Saxon air monitoring network**
- **7. Some results from limited data**
- **8. Work that remains to be done**

1.Measurement methods

- *Discontinuously*

  VDI 2465 Blatt 1:, removal of the organic carbon by solvent desorption with toluene / isopropanol , combustion of the remaining elemental carbon in oxygen at 650 ° C , coulometric measurement of the carbon dioxide produced by combustion . Result of elemental carbon (soot) . Combustion of a non-extracted sample filter provides under the same conditions the amount of total carbon . For total carbon shall apply :

- TC = EC + OC.

- Method is described in 23. BImSchV

1.Measurement methods

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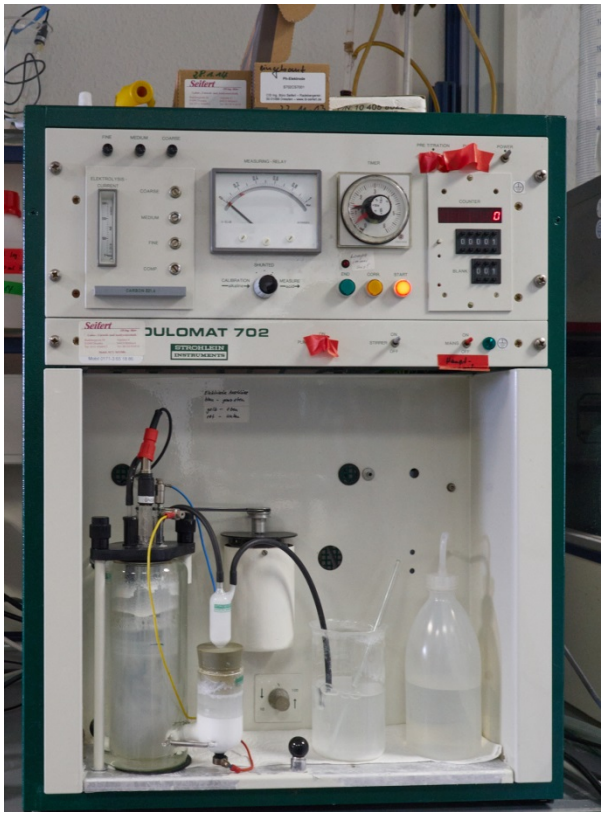

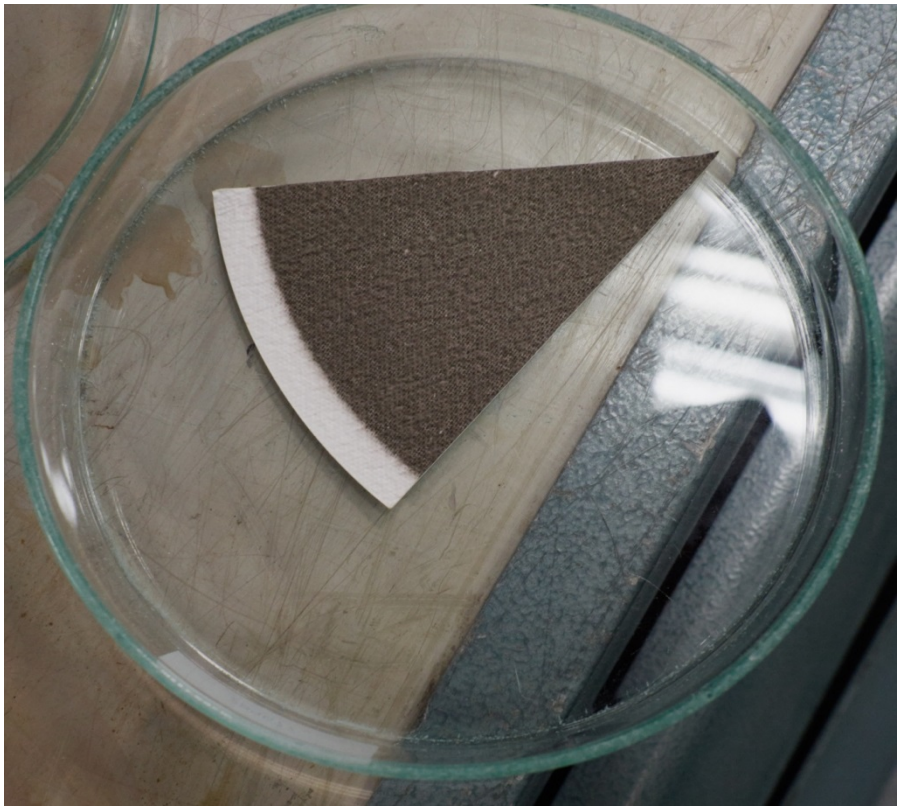

1.Measurement methods

- **VDI → 2465 Blatt 2**
  Thermography

Ramp step	1	2	3	4	5	6	7	8
Temperature	80	350	620	620	400	300	700	80
Hold time	0,2 min	1,2 min	1,2 min	0,6 min	0,3 min	0,5 min	0,9 min	Ende
Process gas	He					He / O_2		
Process name	**Thermodesorption OC**					**Combustion EC**		

The carbon dioxide formed during the combustion is measured by NDIR.

1.Measurement methods

- *continuous (only BC):*

- Aethalometer : measuring the light absorption of the deposited suspended particulate matter on a filter belt

- MAAP (Multi Angel Absorption Photometer): measurement of the light absorption of the deposited particulate matter PM1 or PM10 on a filter belt supported by existing filter reflectance at two different exit angles .

2. Legal regulations

- **23. BImSchV** from 1996-12-16, limit value for elemental carbon has been canceled in 2004. Until 2004 there was a limit value of 10 µg/m^3 at the beginning, lately 8 µg/m^3.

- **39. BImSchV** from 25.01.2010: General formulations for PM2.5 and EC / OC - measurements

3. Measurement history Saxon air monitoring network

- discontiniously: **EC (soot)** and **TC / EC / OC** according to VDI 2465 Bl.1 from PM10-samples deposited on a quarz fibre filter since 2010, red color = measurement has been stopped in 2010

  Monitoring sites: Zwickau, Chemnitz Nord, **Chemnitz Leipziger Straße**, Freiberg, **Dresden Nord, Dresden Bergstraße, Dresden Winckelmannstraße, Görlitz, Leipzig Mitte, Leipzig Lützner Straße, Leipzig West**, Borna, **Radebeul Wahnsdorf, Collmberg**

- conitnuous: **BC** (Aethalometer with TSP from 2001 to 2008), **BC** (MAAP 5012 mit PM10) from 2008 to 2010), **BC** (MAAP with PM1 size selective inlet since 2010)

  Monitoring sites: **Dresden Nord**, **Dresden Nord**, **Dresden Nord**, **Dresden Winckelmannstraße**, **Annaberg Buchholz**

4. Procedures of other departments for monitoring air quality in Germany

- Measurments of EC until 2004 (limit value for soot has been canceled) using filter devices according to VDI 2465 Bl. 1 or 2
- Since 2004 stop or comprehensive reduction for monitoring soot by filter devices
- Use of aethalometer / soot photometer to analyse BC, introducing of different hardware news
- Since 2008 also use of MAAP-2012 (Thermo Fisher) for monitoring BC
- Since 2012 testing of a new methode of thermography with optical detection for the volatile fraction of soot (TOT / TOR; TO = thermal optical procedure, T = transmission, R = reflection)

5. The problem of quality assurance

- **Standardization**
  - For discontinuously estimation of EC and OC:
    VDI 2465 Blatt 1: December 1996, production of equipment has been finished 10 years ago, there is no support available
    VDI 2465 Blatt 2: Mai 1999
  - New European design for a standard method using TOT / TOR and EUSAAR II programme to ramp process temperatures and gases(CEN/TR 16243)
  - Continuous Determination of BC:
  - No standard procedure available, but some different optical methods in use

5. The problem of quality assurance

- **Reference materials**
  - For VDI 2465 Blatt 1 and 2 and for TOT / TOR synthetic standards without reference to environmental and aerosol sampling (oxalic acid, sugar, methane...)
  - No reference materials for continuous optical determination by light absorption available. Initial studies of the TROPOS with Printex as black carbon reference material by quantification using Raman spectroscopy has been published
- **Reference methods**
  - By definition of 23. BImSchV : VDI 2465 Blatt 1 for estimating EC
  - Reference methods BC : temporary not available. (replacement)solution : Round Robin Test

6. The approach of the Saxon air monitoring network

- Procurement of a Sunset EC - OC - analyzer with optical mapping of the volatile fraction by a simultaneous reflection and transmission measurement path using the EUSAAR II temperature programme
- Installation of the equipment in order lab at the expense of BfUL
- Parallel measurement of samples from the monitoring network operation using VDI 2465 Blatt 1 and TOT / TOR for about 12 months
- Analysis of the data for determining a transfer function that allows an exchange of the old data in measuring value by TOT / TOR and vice versa
- Comparison of the results with the findings from other monitoring networks and TROPOS

6. The approach of the Saxon air monitoring network

- Release of TOR - proceedings by the LfULG for the Saxon air monitoring network
- No release of TOR - proceedings by the LfULG : Continuation of the VDI method is not secure

Temperature and process gas programme for TOT / TOR – method using EUSAAR II

Ramp step	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Temperature	200	300	450	650	500	550	700	850
Hold time	120 s	150 s	180	180 s	120 s	120 s	70	80 s
Process gas	He				He / O_2			
Process name	**Thermodesorption OC**					**Combustion EC**		

6. The approach of the Saxon air monitoring network

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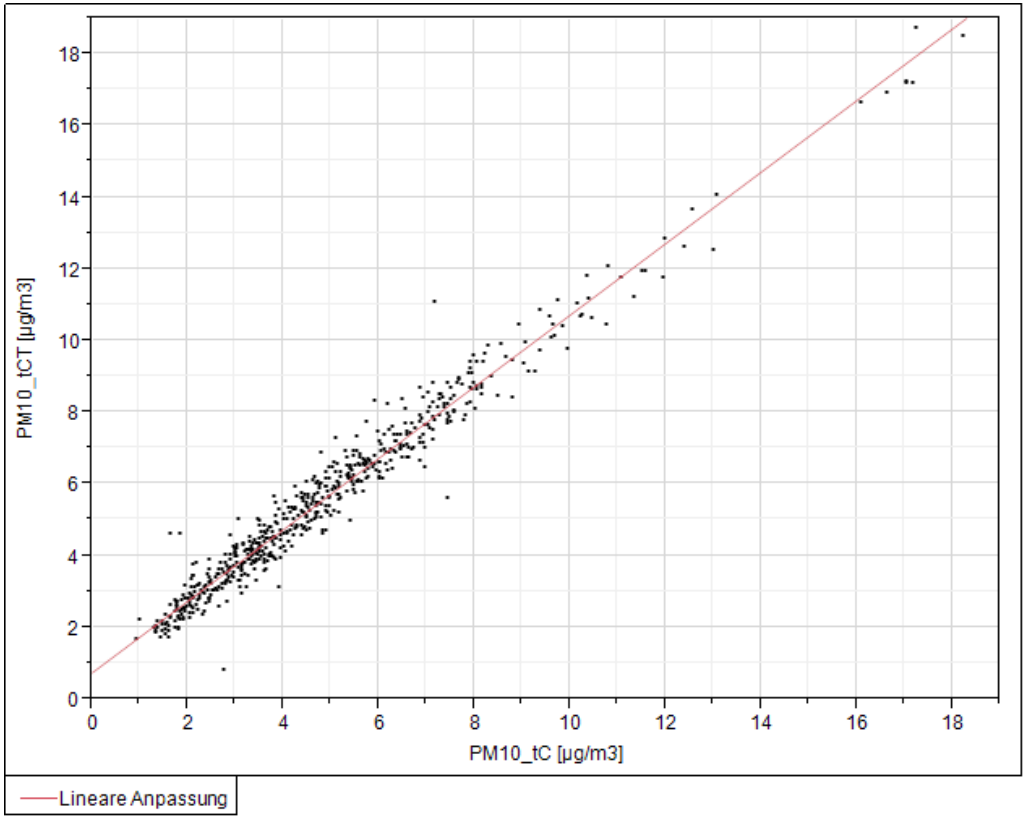
7. Some results from limited data

all data measured in reflection!

tCT = f (tC)



Lineare Anpassung

PM10_tCT [µg/m3] = 0,7477254 + 0,9977351*PM10_tC [µg/m3]

Übersicht der Anpassung

r^2	0,966892
r^2 korrigiert	0,966837
Wurzel der mittleren quadratischen Abweichung	0,486766
Mittelwert der Zielgröße	5,631581
Beobachtungen (oder Summe Gewichte)	601

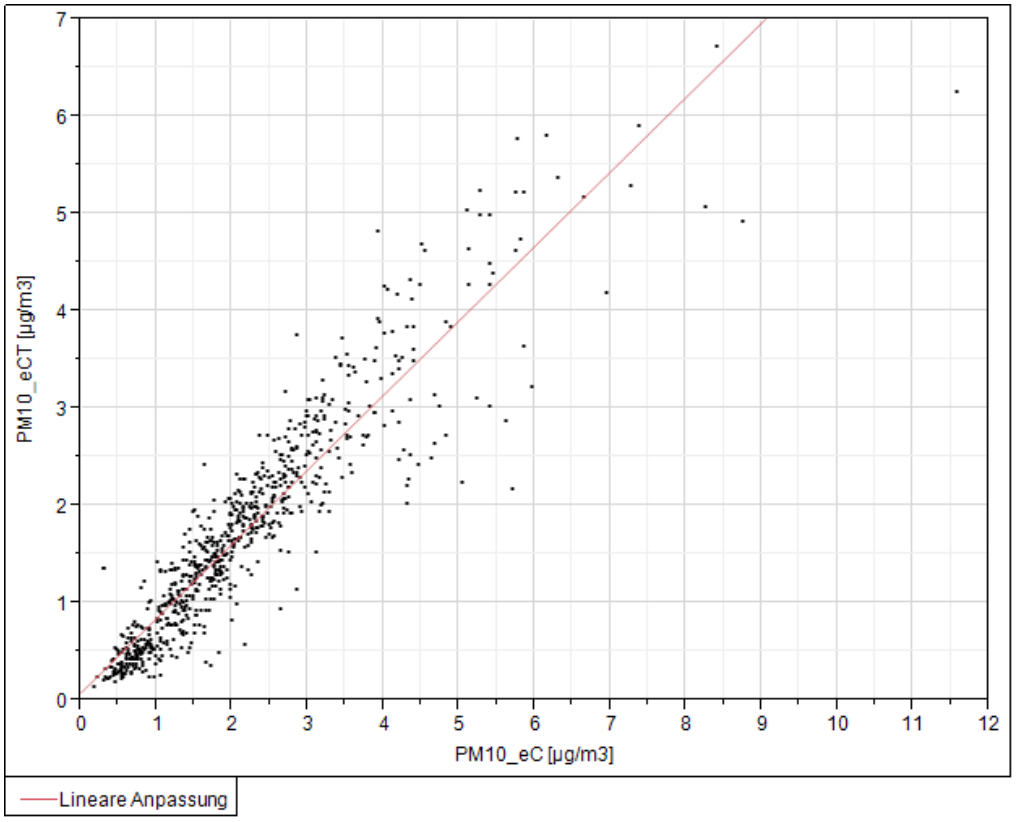
Parameterschätzer

Term	Schätzer	Std.-Fehler	t-Wert	Wahrsch.>|t|
Achsenabschnitt	0,7477254	0,041925	17,83	<,0001*
PM10_tC [µg/m3]	0,9977351	0,007544	132,26	<,0001*

linear adjustment : tCT [µg/m^3] = 0,997* tC [µg/m^3] + 0,748

7. Some results from limited data

eCT = f (eC)



Lineare Anpassung

PM10_eCT [µg/m3] = 0,0782117 + 0,7655737*PM10_eC [µg/m3]

Übersicht der Anpassung

r^2	0,853911
r^2 korrigiert	0,853716
Wurzel der mittleren quadratischen Abweichung	0,424574
Mittelwert der Zielgröße	1,720719
Beobachtungen (oder Summe Gewichte)	751

Parameterschätzer

Term	Schätzer	Std.-Fehler	t-Wert	Wahrsch.>|t|
Achsenabschnitt	0,0782117	0,029262	2,67	0,0077*
PM10_eC [µg/m3]	0,7655737	0,01157	66,17	<,0001*

linear adjustment : eCT [µg/m^3] = 0,766 * eC [µg/m^3] + 0,078

7. Some results from limited data

- Transfer function for TC to the Saxon monitoring sites

Site name	typ	Slope	intersection	quality
Collmberg	background	1,004	0,644	0,978
Dresden-Bergstr.	hot spot	0,964	1,054	0,963
Dresden-Nord	urban	1,026	0,751	0,939
Dresden-Winckelmannstr.	Background	0,987	0,743	0,963
Leipzig West	Background	0,969	0,779	0,950
Leipzig-Lützner Str.	hot spot	0,974	0,871	0,962
Leipzig-Mitte	urban	0,984	0,741	0,951
Radebeul-Wahnsdorf	background	0,999	0,865	0,967

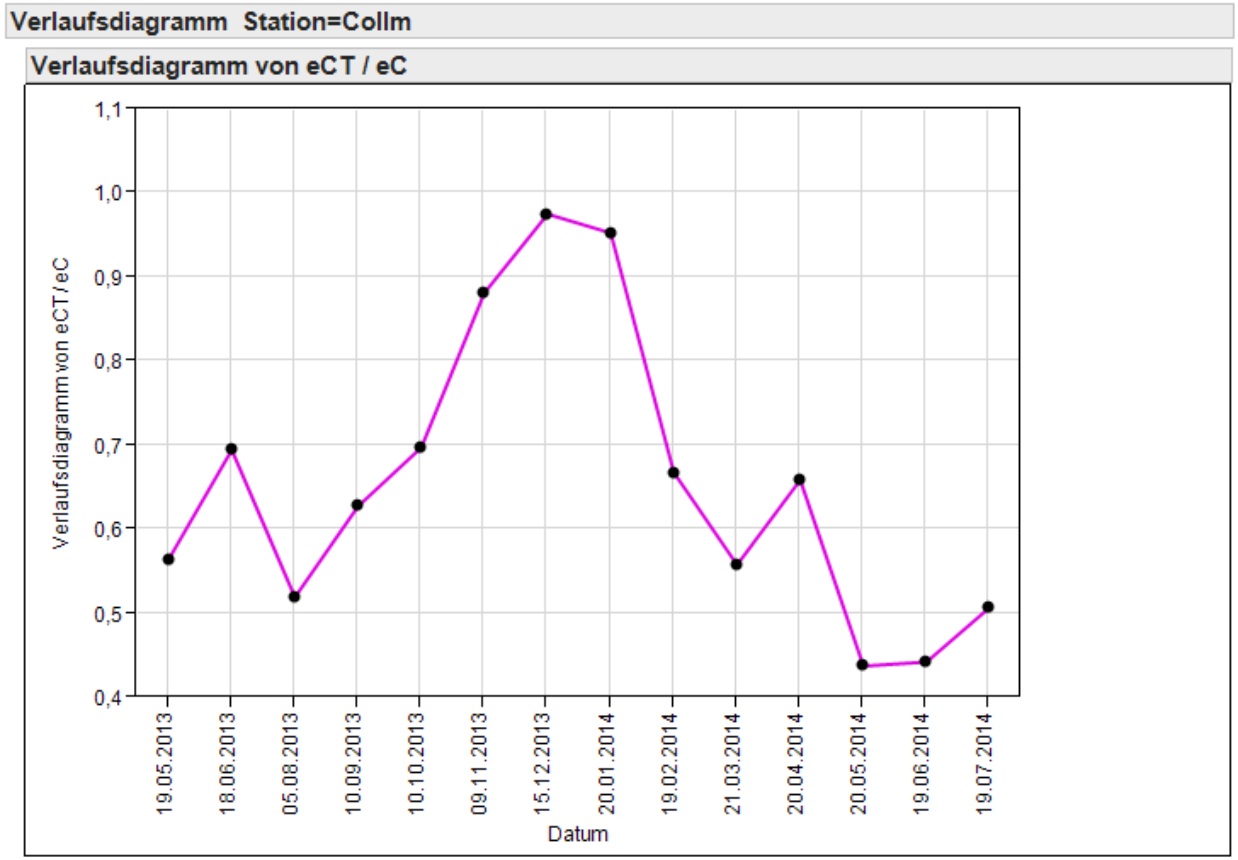
7. Some results from limited data

- Transfer function for EC to the Saxon monitoring sites

Site name	typ	Slope	intersection	quality
Chemnitz Leipziger Str.	hot spot	0,709	0,323	0,842
Collmberg	background	0,732	-0,081	0,868
Dresden-Bergstr.	hot spot	0,719	0,488	0,697
Dresden-Nord	urban	0,695	0,372	0,712
Dresden-Winkelmannstr.	background	0,661	0,155	0,849
Görlitz	urban	0,572	0,589	0,841
Leipzig West	background	0,784	-0,165	0,894
Leipzig-Lützner Str.	hot spot	0,715	0,176	0,716
Leipzig-Mitte	urban	0,747	0,262	0,840
Radebeul-Wahnsdorf	background	0,819	-0,046	0,838

7. Some results from limited data

Monthly average for the ratio TOR / VDI eC - Examples



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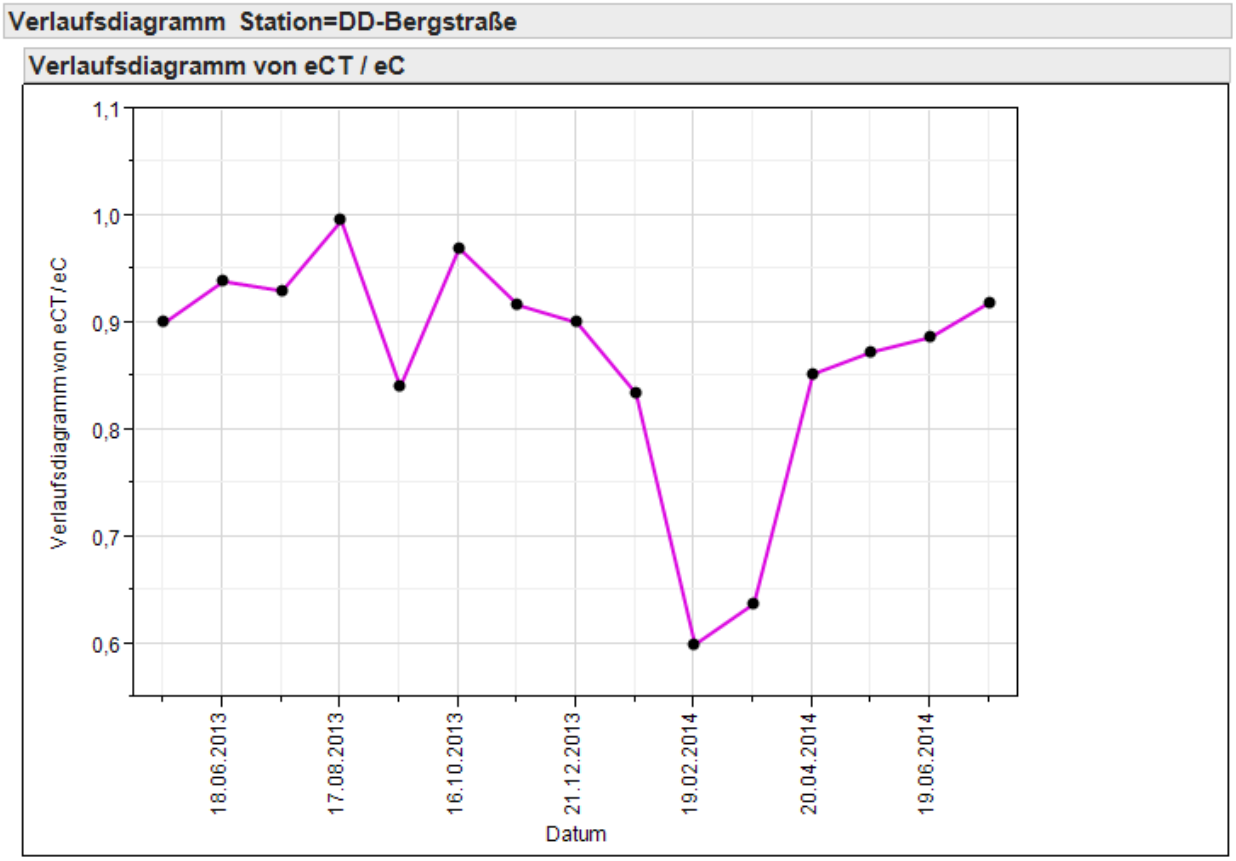
Monthly average for the ratio TOR / VDI eC - Examples



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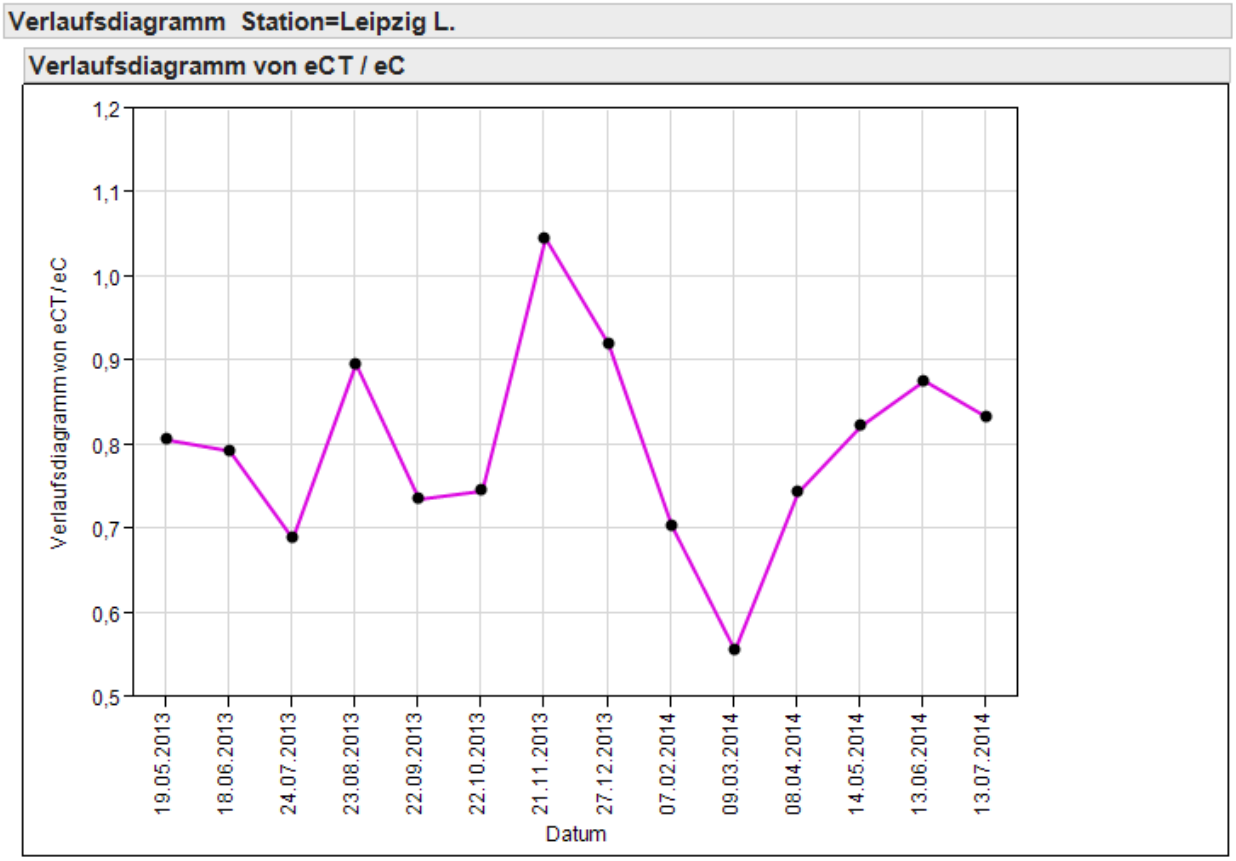
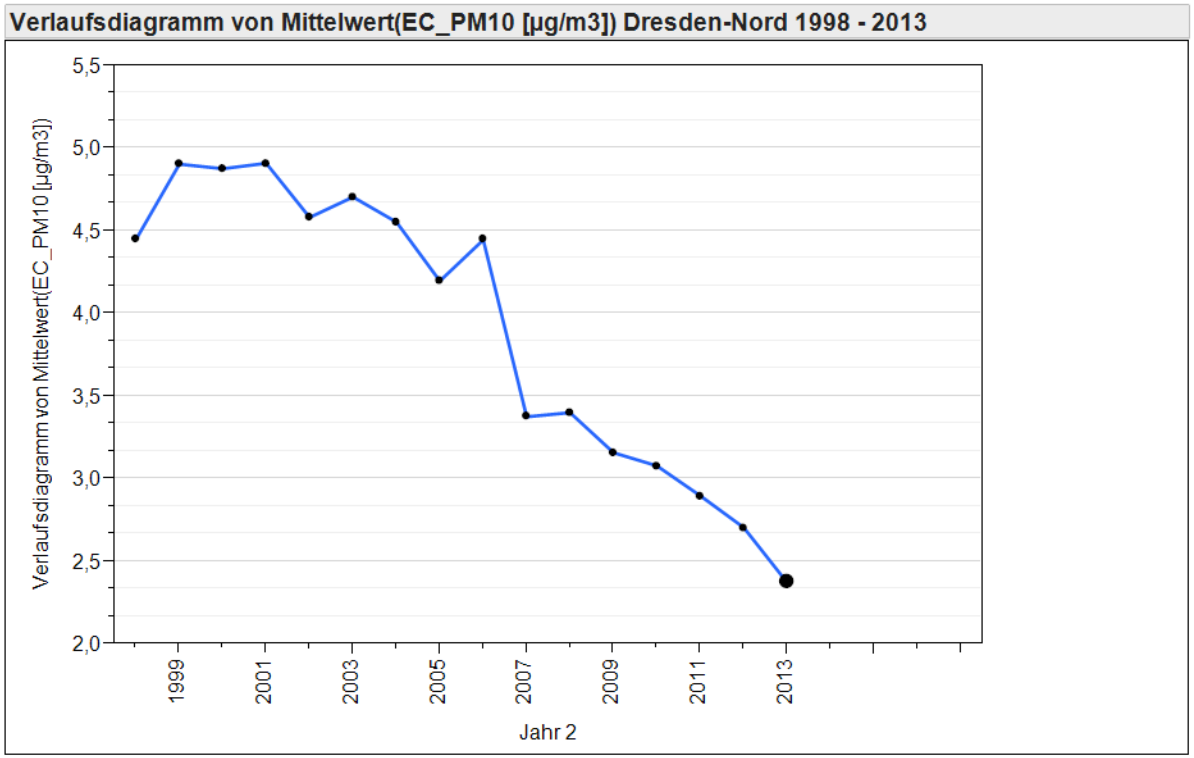
Monthly average for the ratio TOR / VDI eC - Examples



8. Work that remains to be done

- **Development of air quality situation in relevant Saxon monitoring sites**
- **Dresden Nord:**



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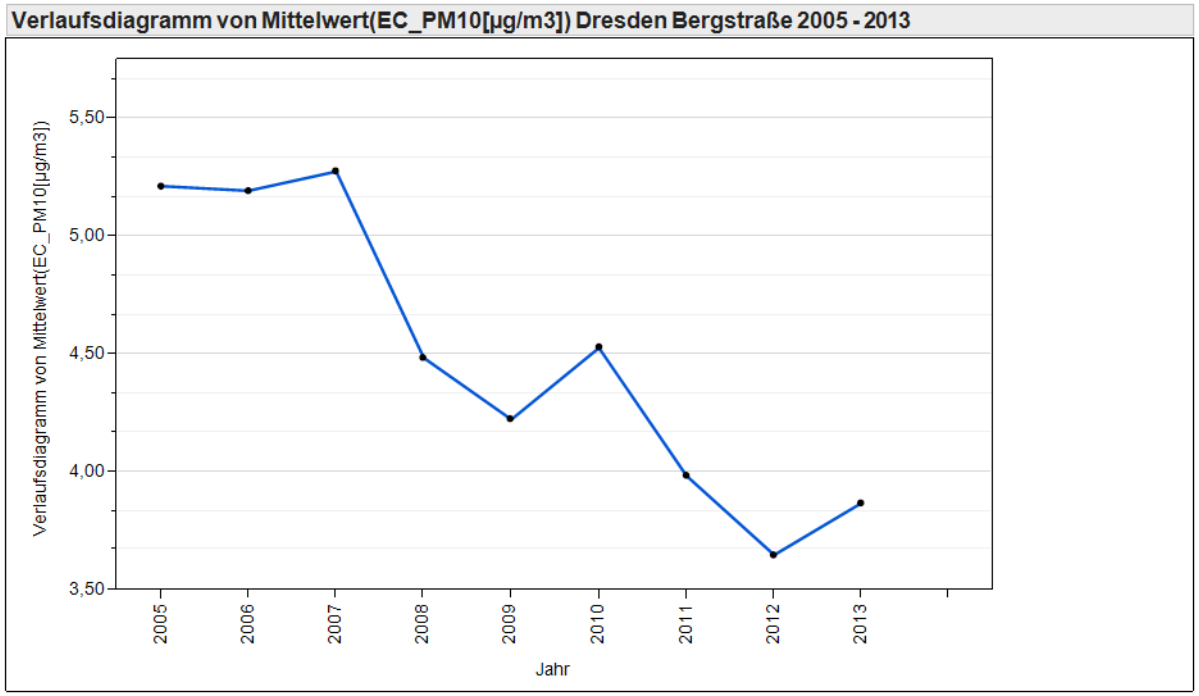
- **Dresden Bergstraße:**



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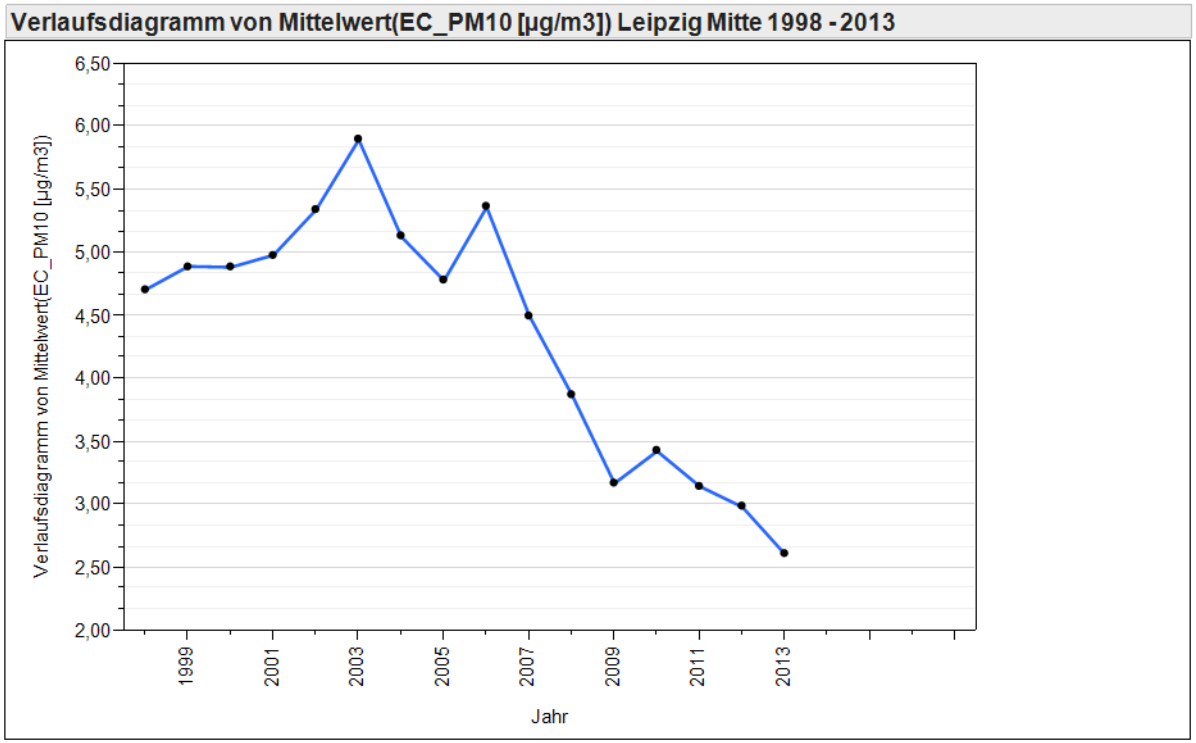
- **Development of air quality situation in relevant Saxon monitoring sites**
- **Leipzig Mitte:**



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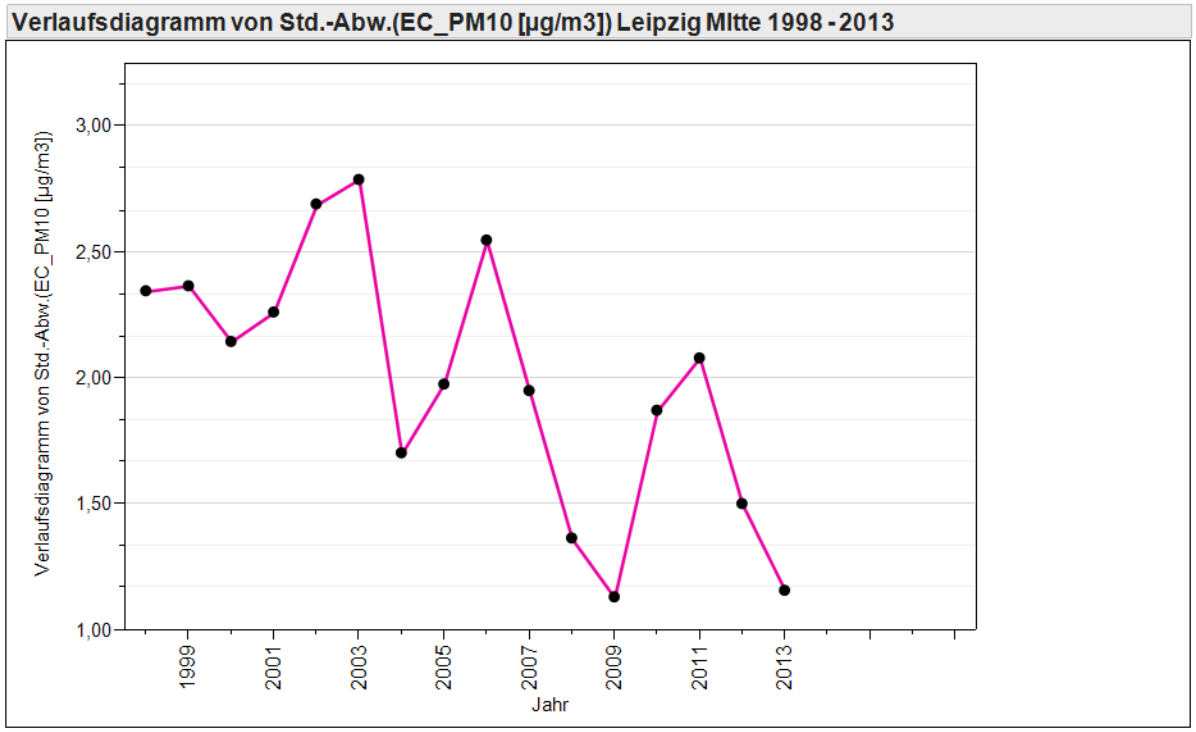
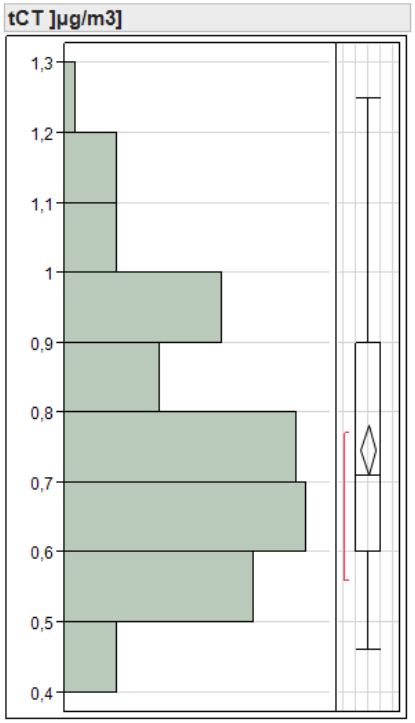


8. Work that remains to be done

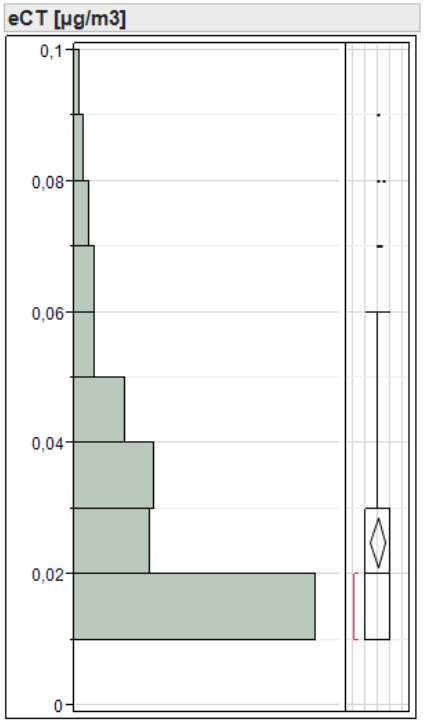
Field blank values for TOR eC and tC

- High entry through storage in the station, transport and handling for tC 90 % quartile of approximately 1,0 µg/m³ !
- lower contribution field blank value for eC 90 % quartile of 0.06 µg/m³
- Filter-based tC measurement seems to be deficult for expected values less than 2.5 µg/m³



Quantile		
100.0 %	Maximum	1,25
99.5 %		1,25
97.5 %		1,174
90.0 %		1,018
75.0 %	Quartil	0,9
50.0 %	Median	0,71
25.0 %	Quartil	0,6
10.0 %		0,52
2.5 %		0,48
0.5 %		0,46
0.0 %	Minimum	0,46

Statistische Kenngrößen	
Mittelwert	0,7467961
Std.-Abw.	0,1834966
Std.-Fehler Mittelwert	0,0180805
95% KI oben Mittelwert	0,7826586
95% KI unten Mittelwert	0,7109336
N	103



Quantile		
100.0 %	Maximum	0,09
99.5 %		0,09
97.5 %		0,08
90.0 %		0,056
75.0 %	Quartil	0,03
50.0 %	Median	0,02
25.0 %	Quartil	0,01
10.0 %		0,01
2.5 %		0,01
0.5 %		0,01
0.0 %	Minimum	0,01

Statistische Kenngrößen	
Mittelwert	0,0248544
Std.-Abw.	0,0191927
Std.-Fehler Mittelwert	0,0018911
95% KI oben Mittelwert	0,0286054
95% KI unten Mittelwert	0,0211033
N	103

8. Work that remains to be done

- Continuation of the series of measurements with the methods currently used
- Decision to the monitoring network analysis for the Saxon air monitoring network
- Abreast of developments in the field of standardization
- Participation in nationwide workshops and working groups on the issue of measurement of TC , EC, OC , BC