A 24 year long-term trend for PM at Melpitz site in Germany – Results for different Weather Type Classification Methods

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16TH INTERNATIONAL CONFERENCE ON CHEMISTRY AND THE ENVIRONMENT (ICCE), Oslo, Norway, 18.06. – 22.06.2017

Leibniz-Gemeinschaft

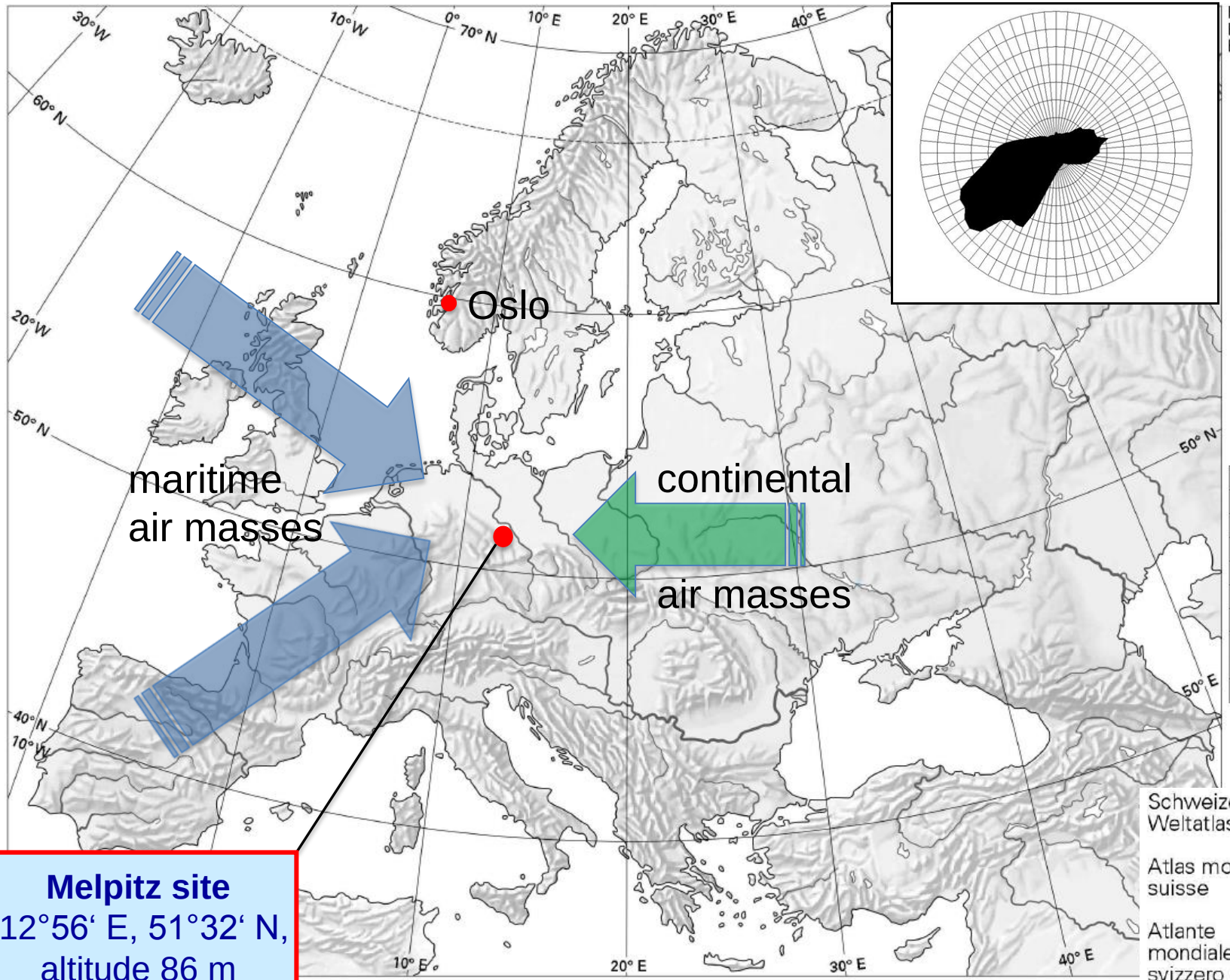
TROPOS
Leibniz-Institut für Troposphärenforschung

emep
Co-operative programme for monitoring and evaluation of the long-range transmissions of air pollutants in Europe

Umwelt Bundesamt

ACTRiS

Location and integration of the TROPOS research site in Europe



German Ultrafine Aerosol Network (GUAN)

MARGA

Europa fördert Sachsen.
EFRE
Europäischer Fonds für regionale Entwicklung

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View to Melpitz site from aircraft with location of HV-samplers

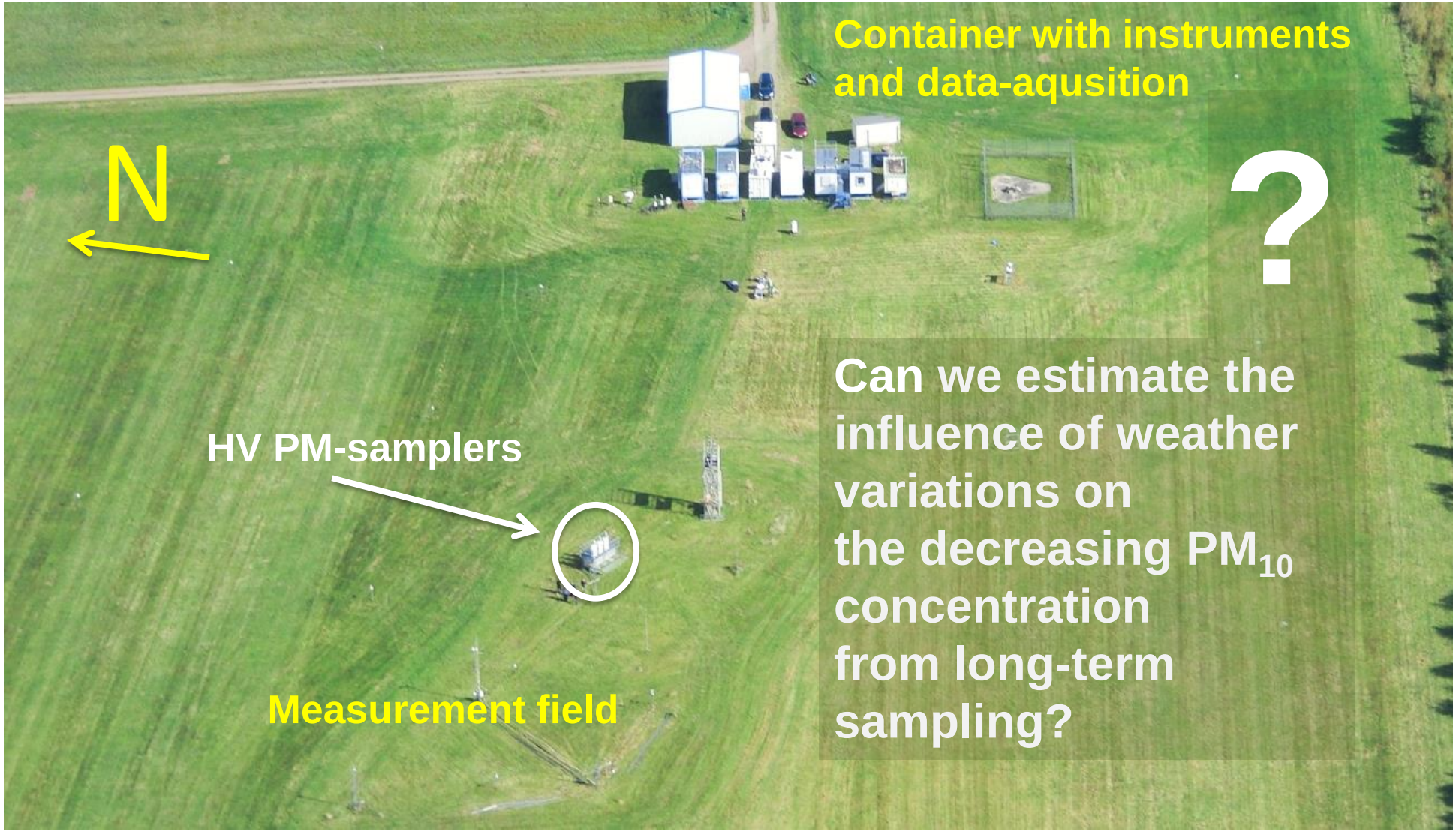

Foto: Holger Siebert, TROPOS

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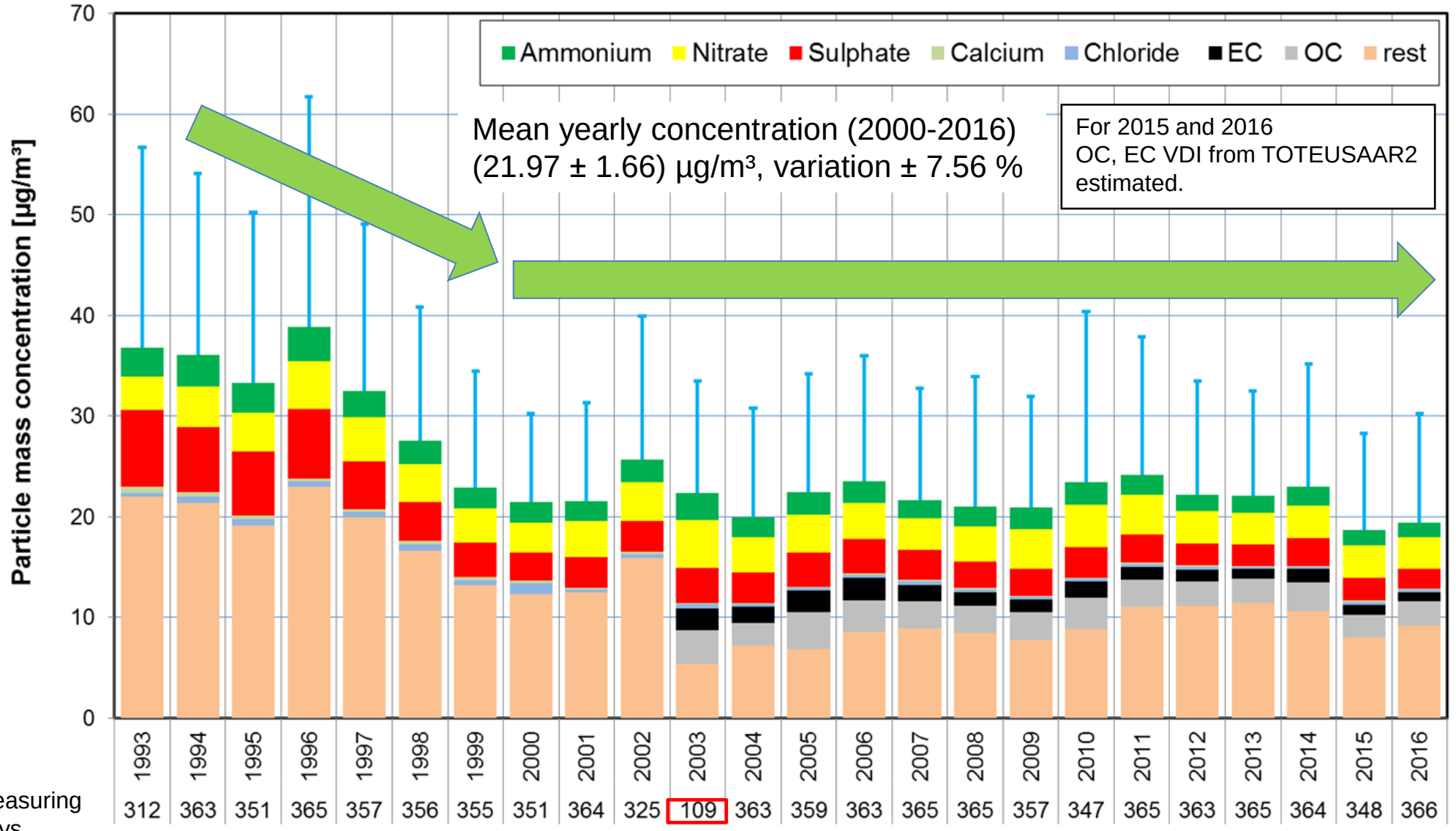
PM_{10} concentration, content of main water soluble ions and carbon since 1993 (yearly means)



12.02.2003 until 09.10.2003 no sampling for PM10

The error bars are the positive standard deviation of daily particle mass concentration means.

HV-filter-sampler

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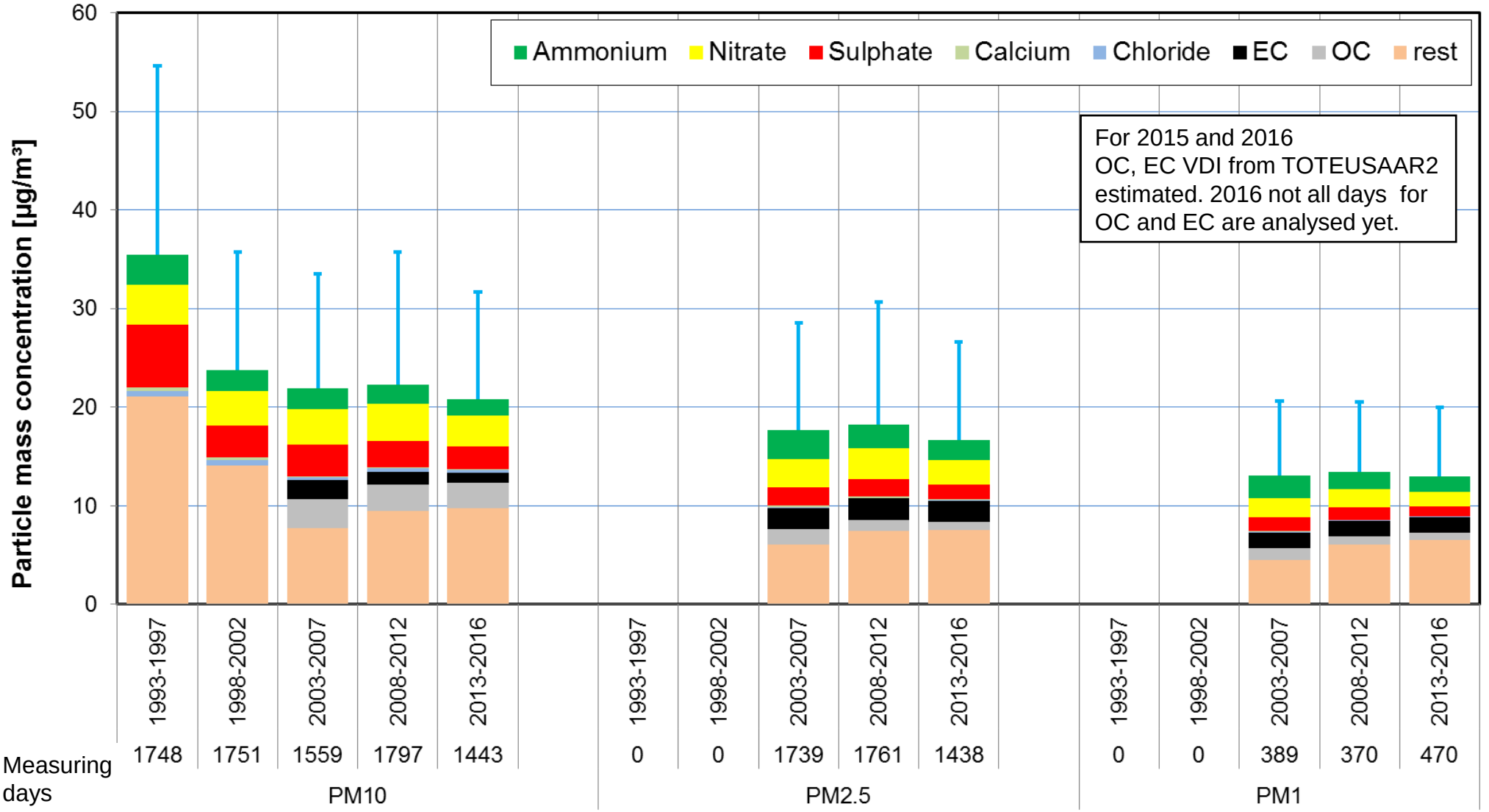
PM_{10}, $PM_{2.5}$ and PM_1 concentration, content of main water soluble ions and carbon since 1993 (five year means)



The error bars are the positive standard deviation of daily particle mass concentration means.

HV-filter-sampler

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Weather type classification methods for sampling days

1. **Simplified subjective categorization of measurement days for air mass inflow West/East (AIWE) by TROPOS**

in comparison with

2. **Objective Weather Type Classification (OWTC) by German Weather Service (DWD)**

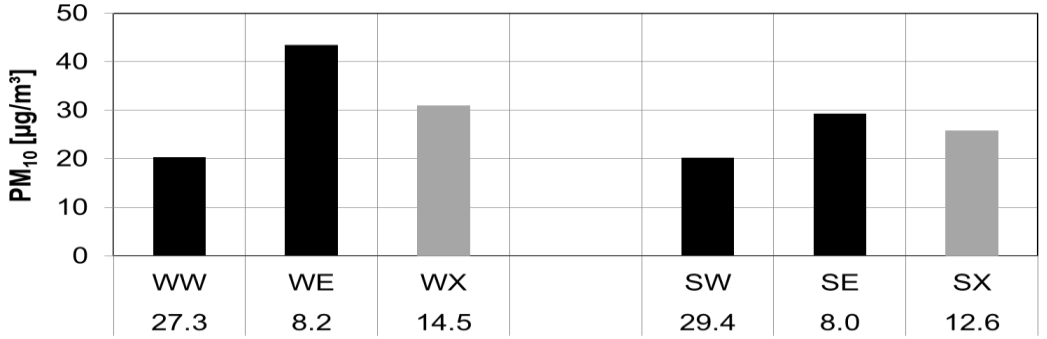
3. **Subjective determined Hess-Brezowsky Classification (SGWL) for *general weather situation* ("Großwetterlagen") by German Weather Service (DWD)**

with additional differentiation for

winter-season:	**November – April**	**(year, end of winter)**
and		
summer-season:	**May – October**	**(year, summer)**

Overview Weather Type Classification Methods and mean PM_{10}-concentrations (11/1992 – 10/2016)

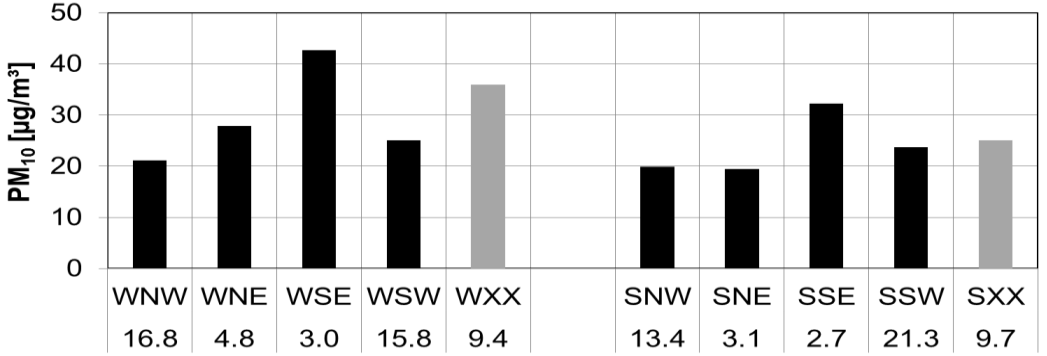
Air mass inflow West/East (AIWE)



72.8 % of all days
for air-mass inflow West and East

35.5 % in winter
37.4 % in summer

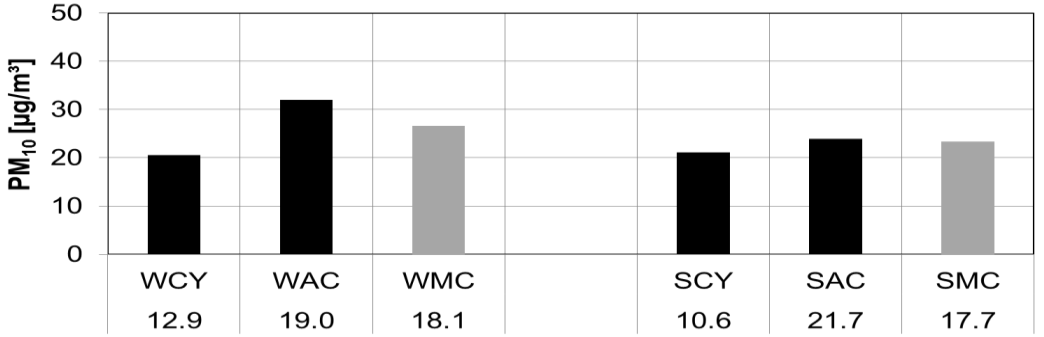
Objective Weather Type Classification (OWTC)



80.8 % of all days are accessed
for wind direction NW, NE, SE, SW

40.4 % in winter
40.5 % in summer

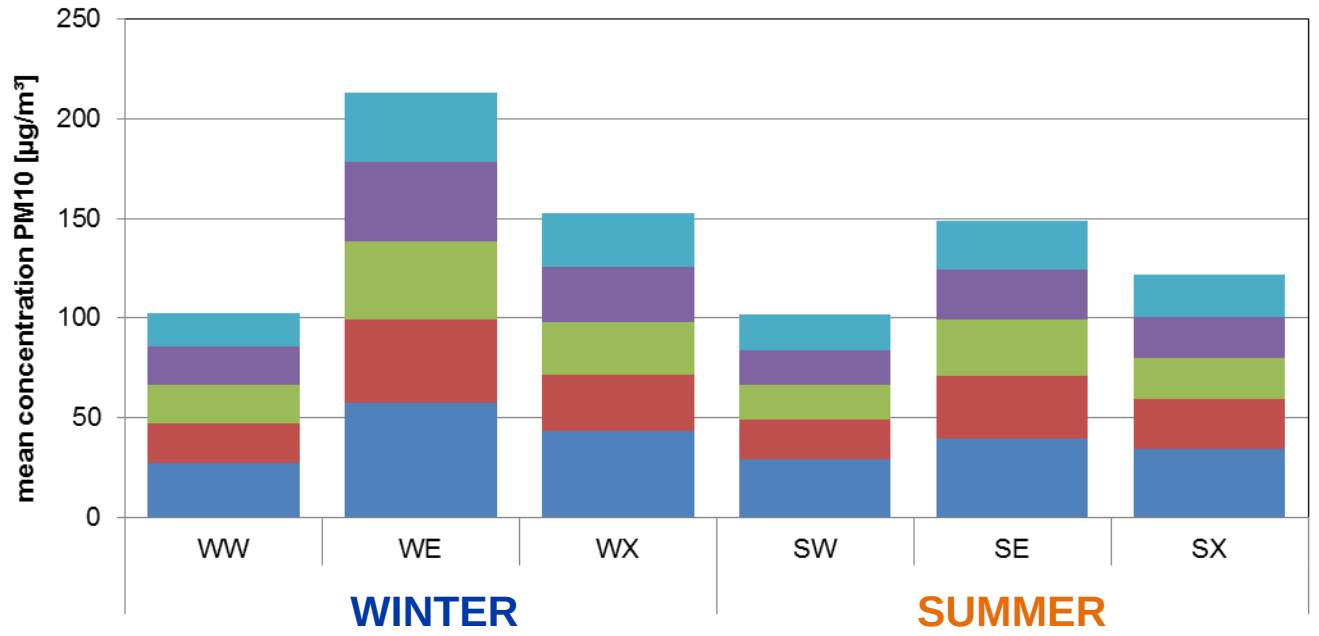
Hess-Brezowsky Classification (SHBC)



64.1 % of all days are accessed
(cyclonic and anticyclonic circulation)

31.9 % in winter
32.3 % in summer

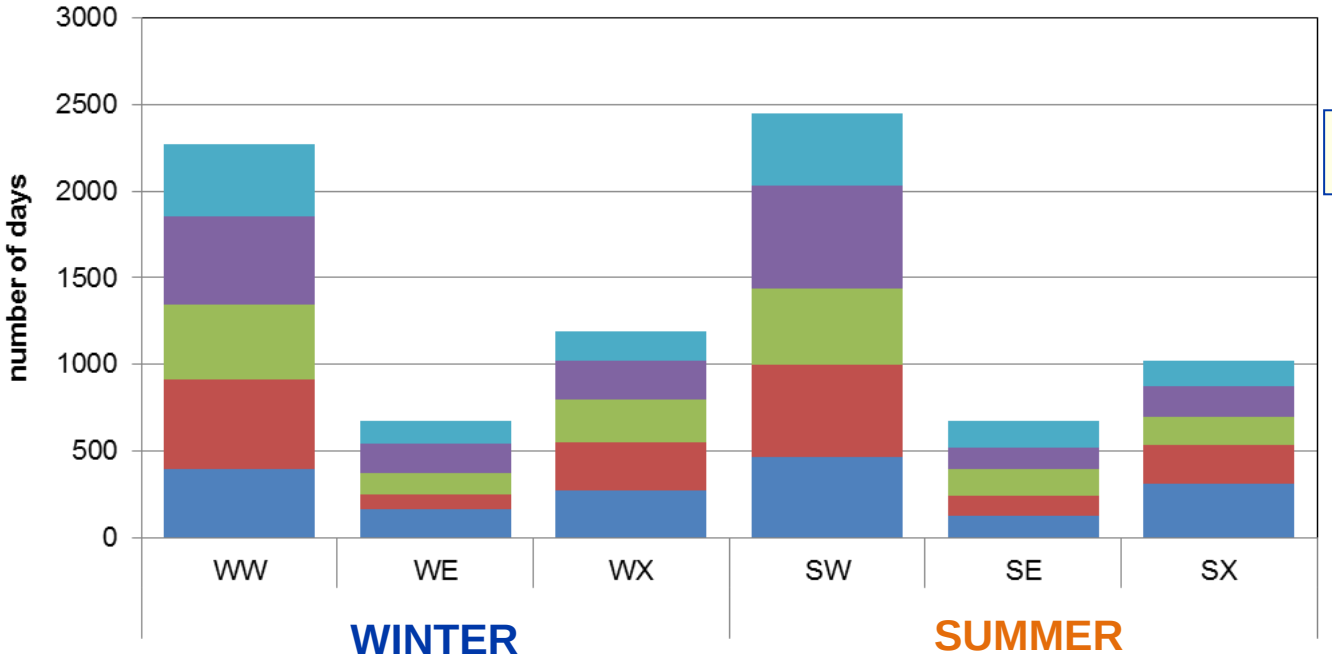
Air mass inflow West/East (AIWE)(11/1992 – 10/2016)



Sum of mean mass-concentration PM_{10}

influence

Daily weather variation



number of measuring Days (#8766)

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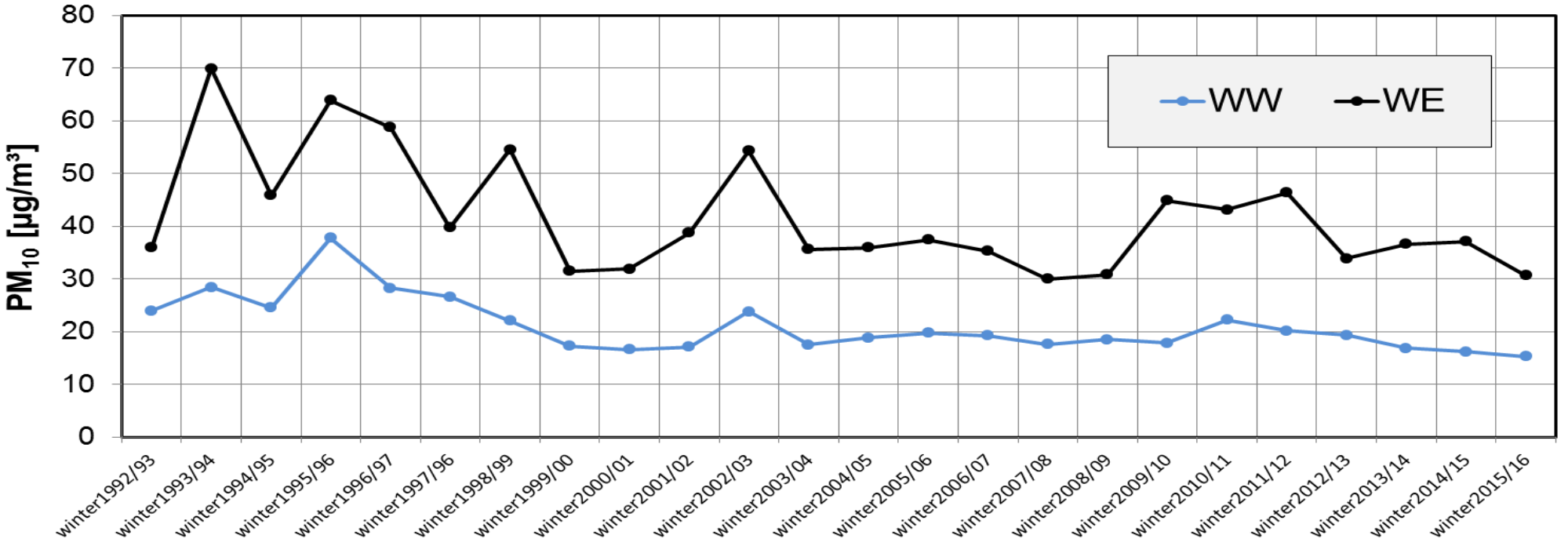
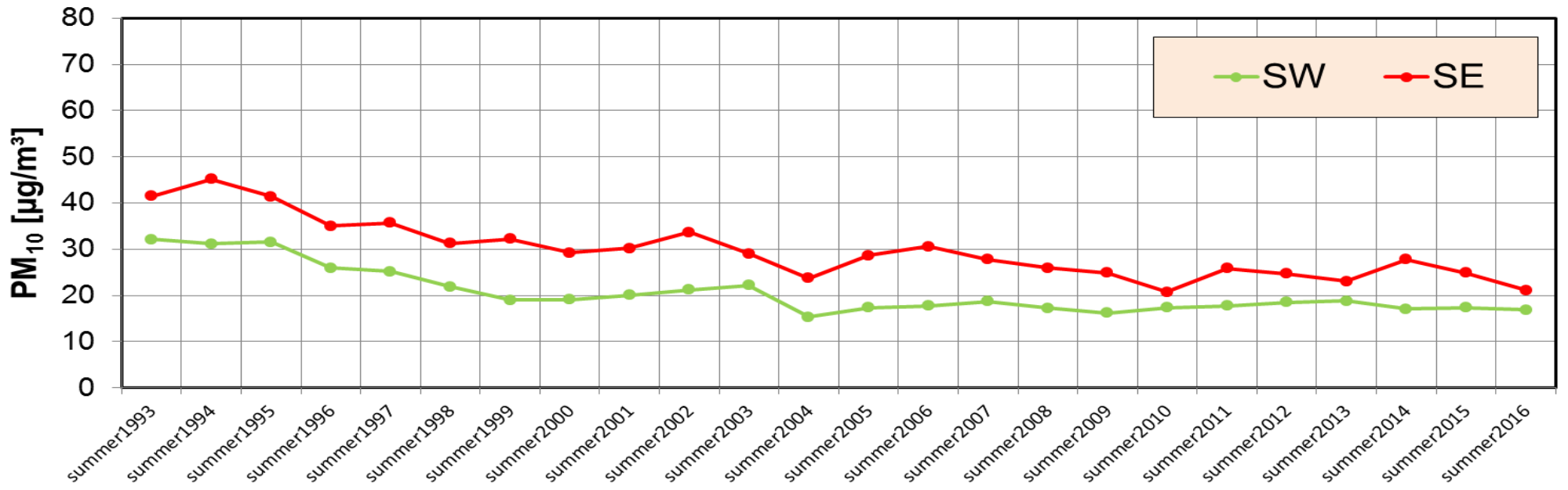
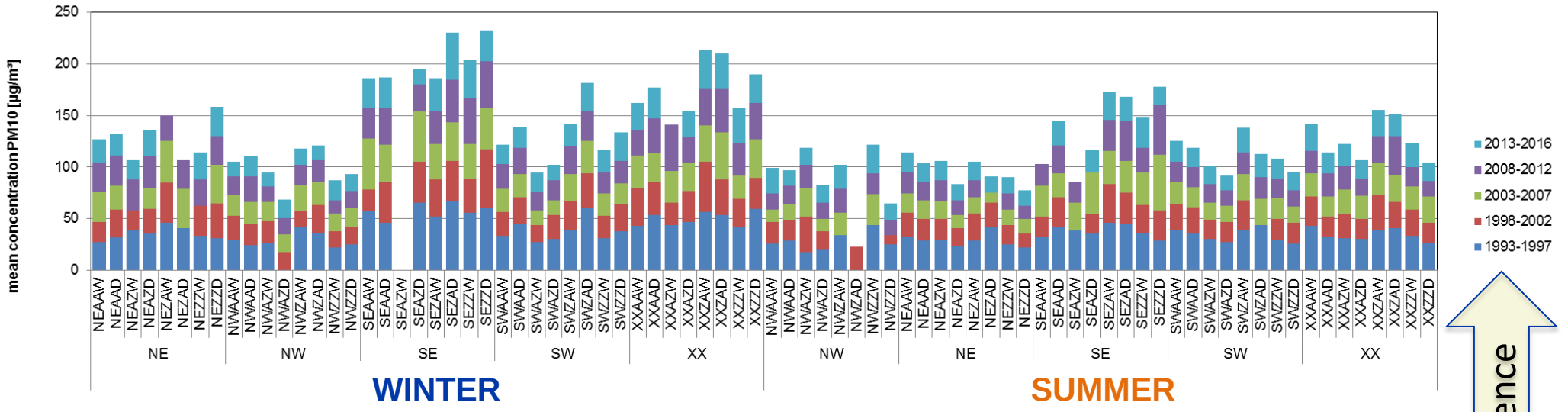
Air mass inflow West/East (AIWE) and PM_{10} concentration (11/1992 – 10/2016)





Objective Weather Type Classification (OWTC) (11/1992 – 10/2016)

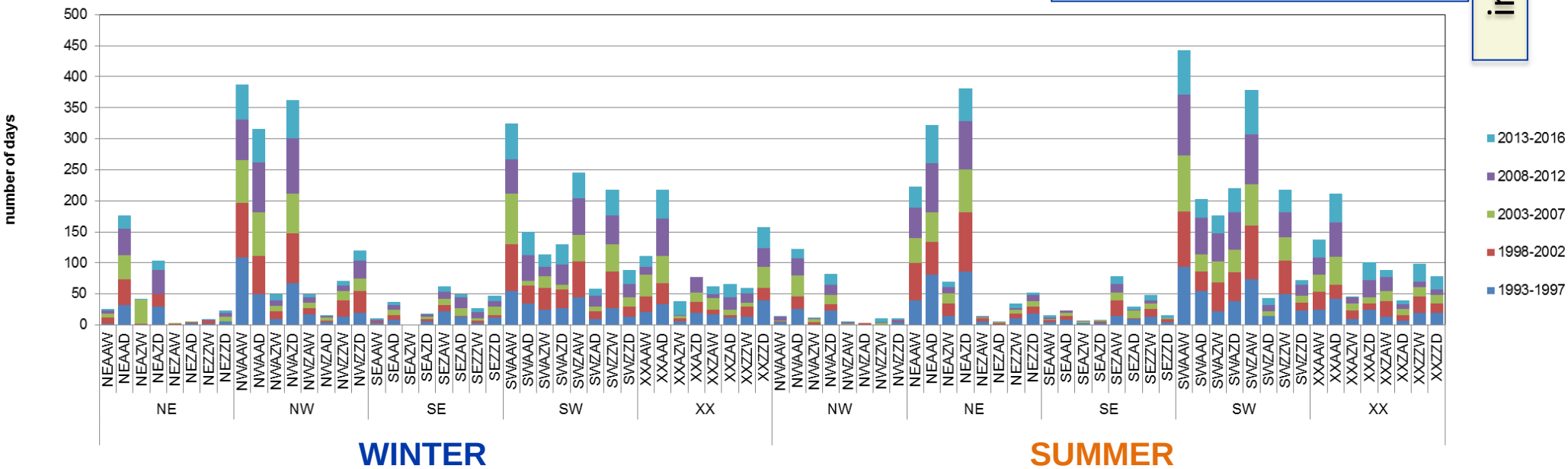
Sum of mean mass-concentration PM_{10}



Daily weather variation

influence

Number of measuring days (#8766)



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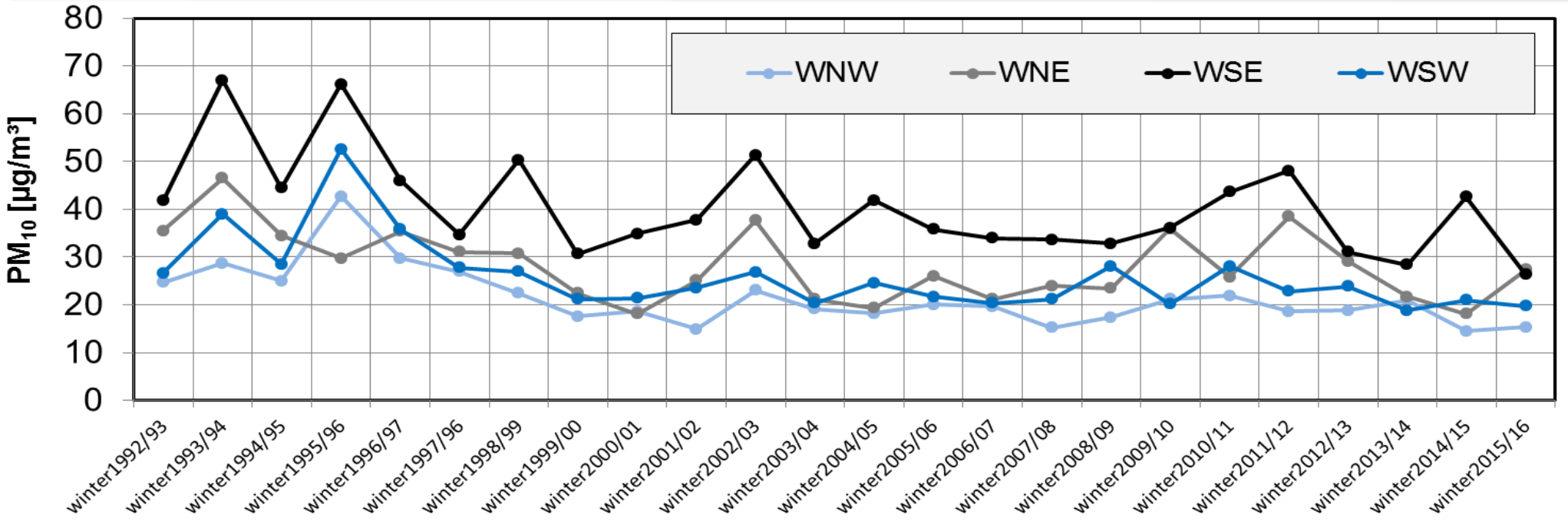
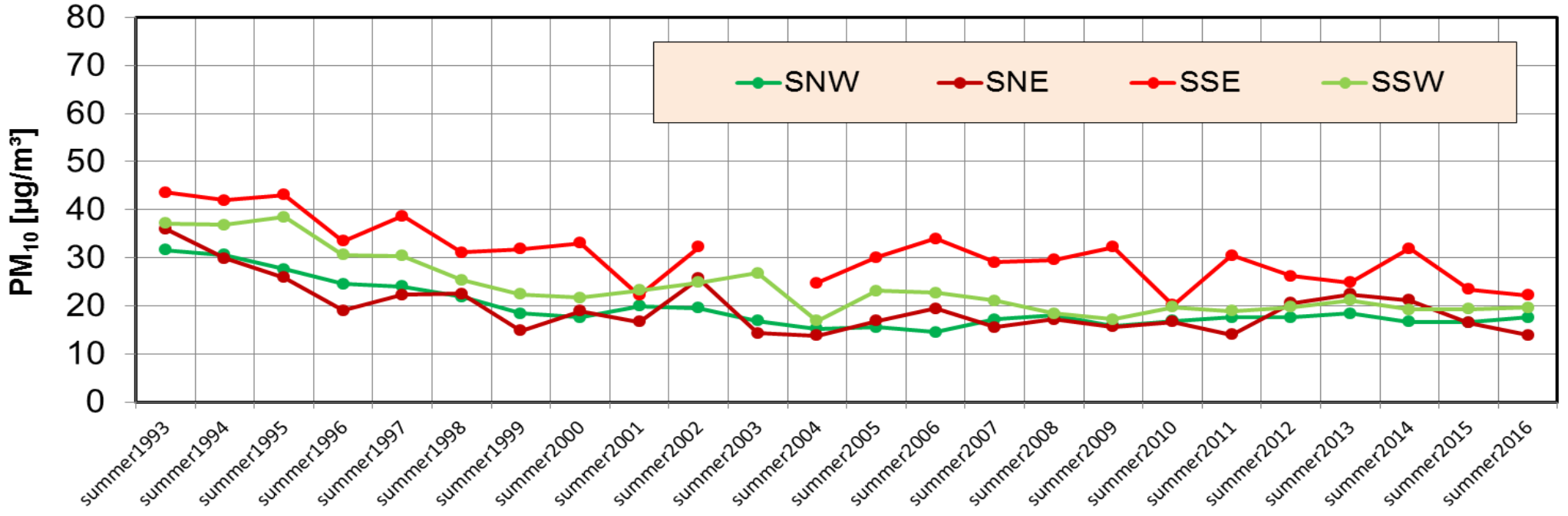
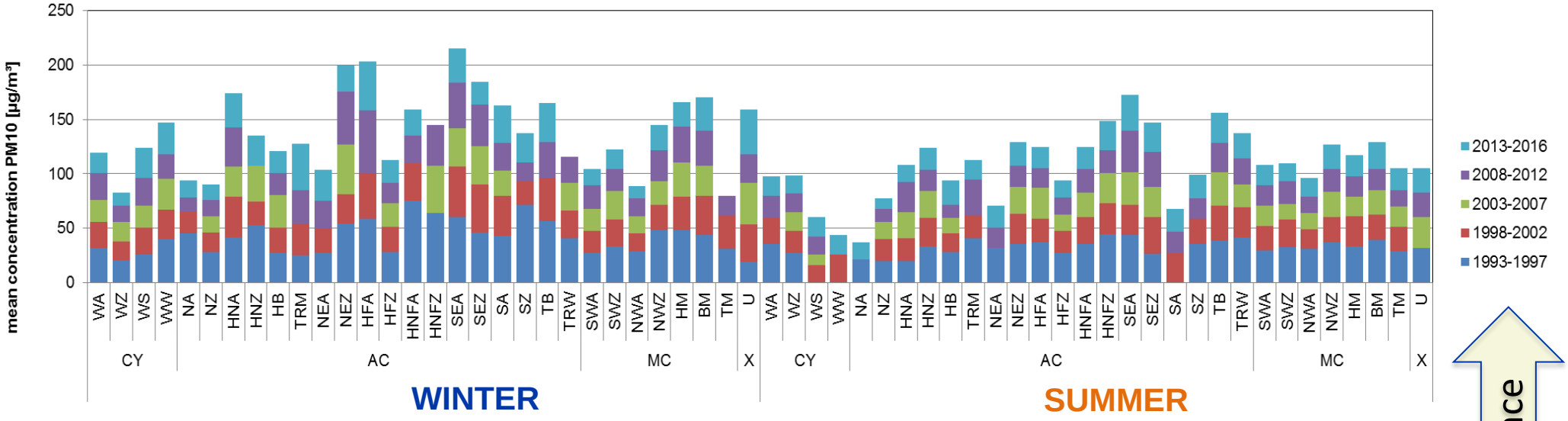
Objective Weather Type Classification (OWTC) and PM_{10} concentration (11/1992 – 10/2016)





Hess-Brezowsky Classification (SHBC) (11/1992 – 10/2016)

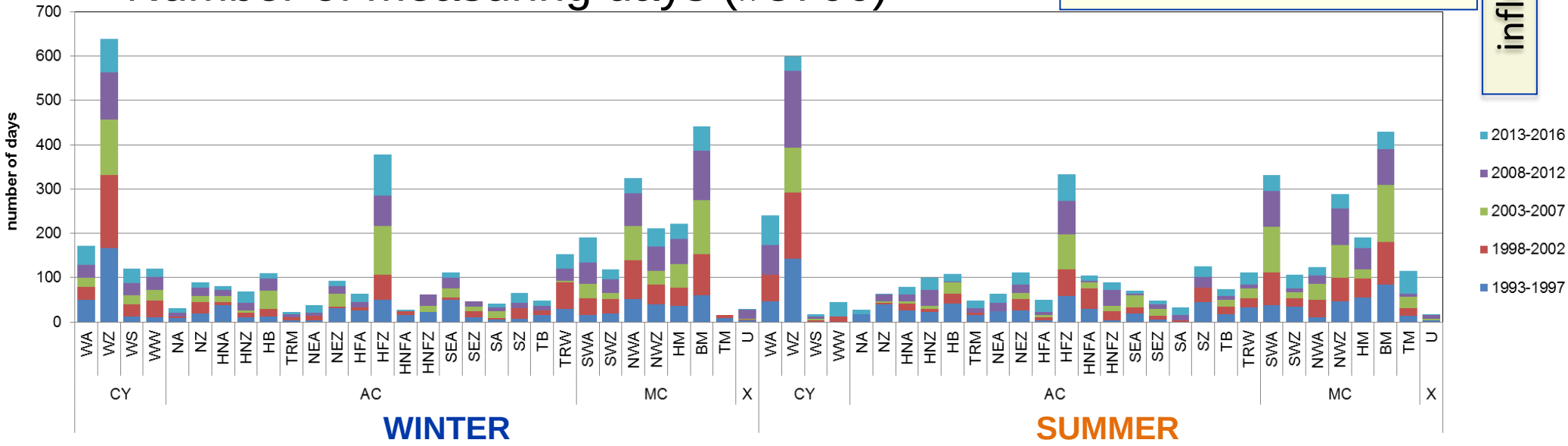
Sum of mean mass-concentrations PM_{10}



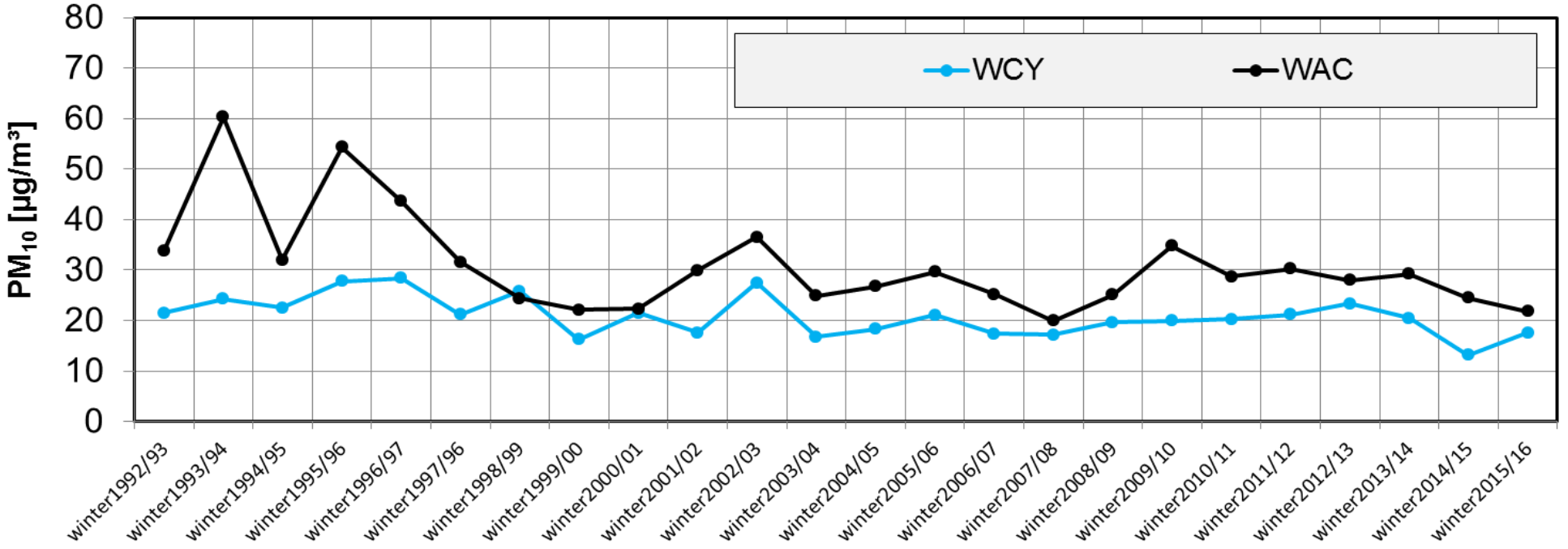
Daily weather variation

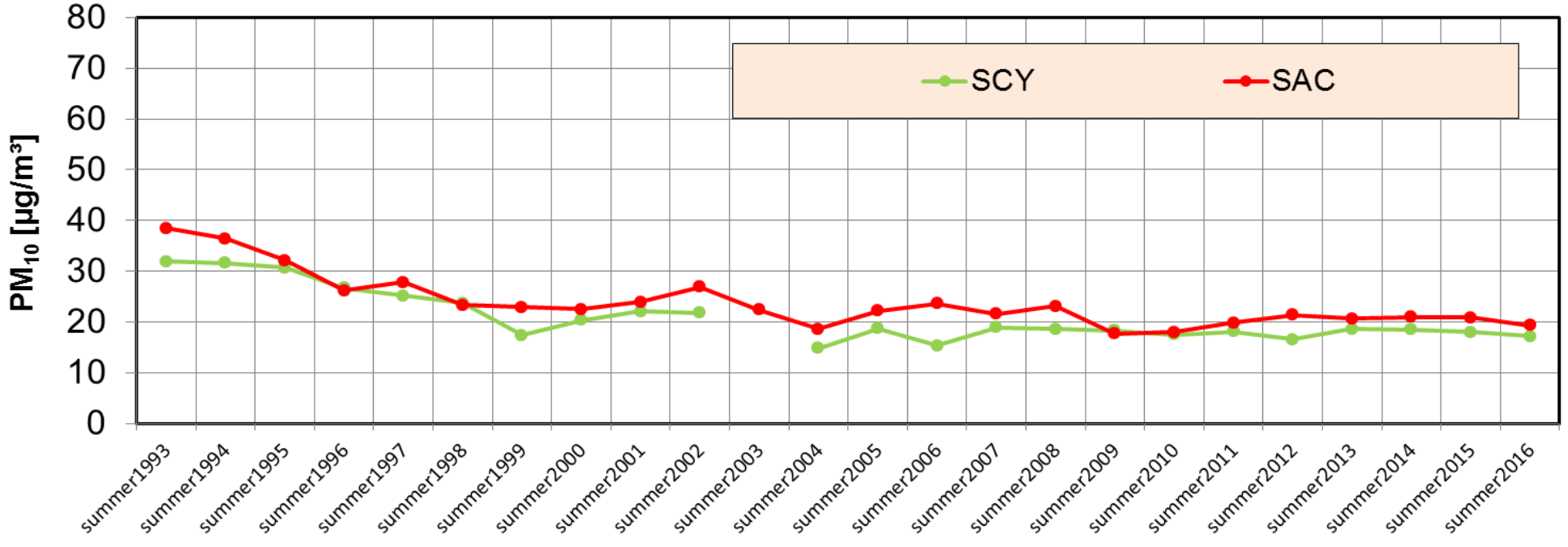
influence

Number of measuring days (#8766)

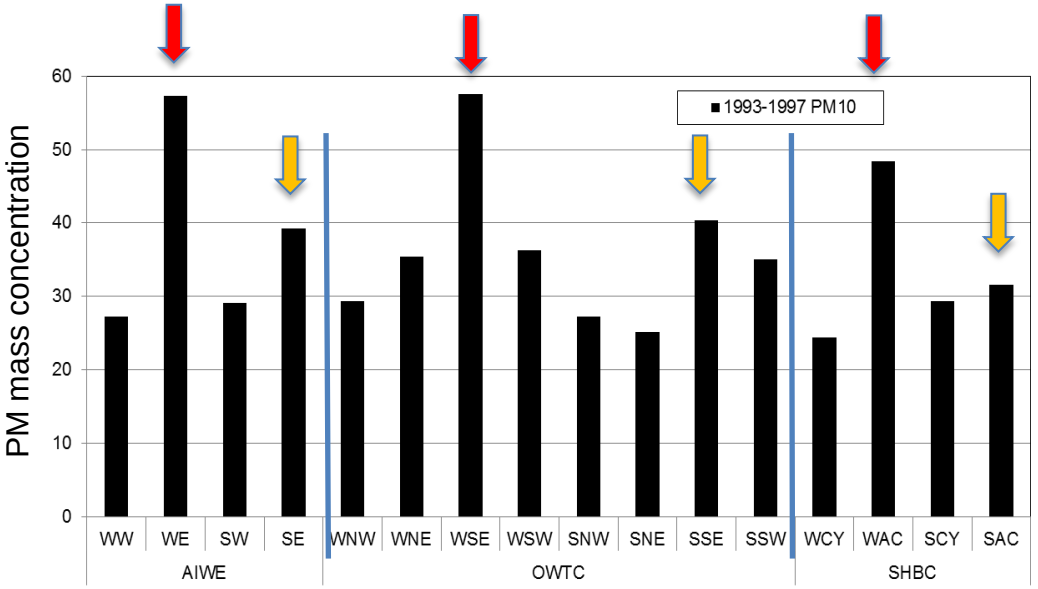


Subjective Hess-Brezowsky Classification (SHBC) and PM_{10} concentration (11/1992 – 10/2016)



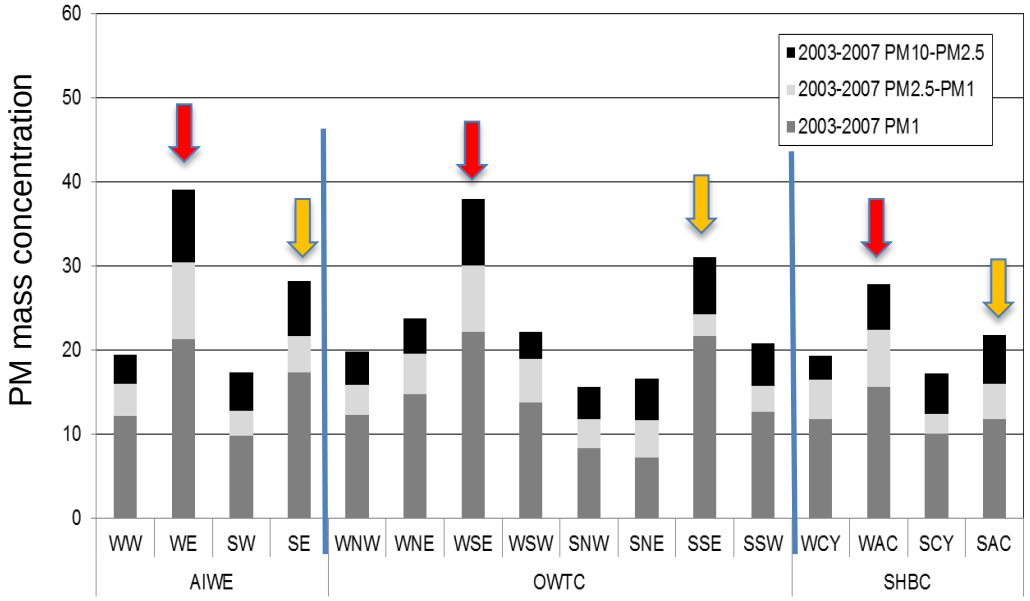


PM_{10}, $PM_{2.5}$ and PM_1 – for the Weather Type Classification Methods (1993-98, 2003-07 and 2013-16)

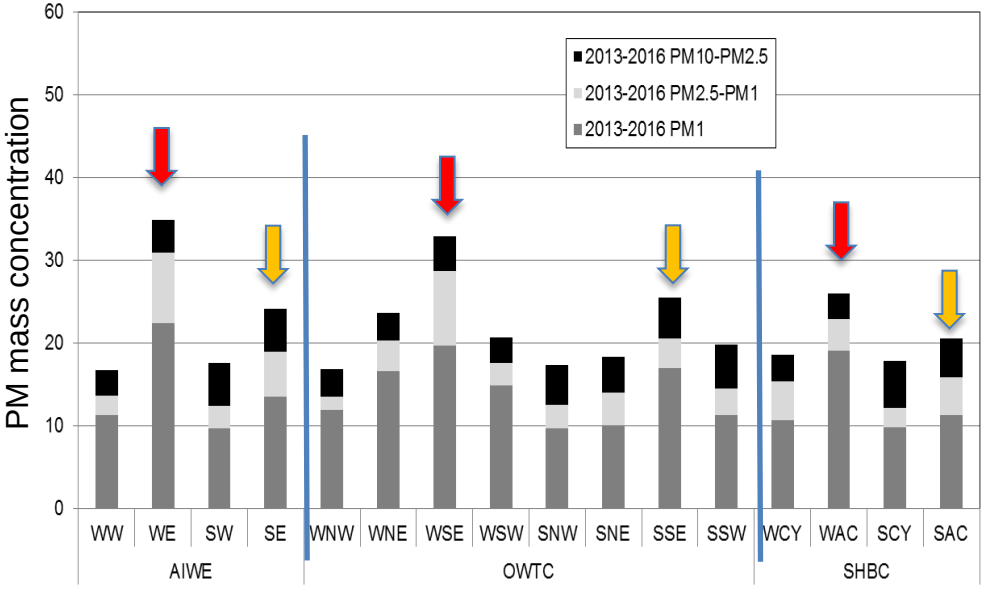


1993-98

The highest mean mass concentrations were found in **continental** air-masses in **Winter** and **Summer** and decline with time.



2003-07

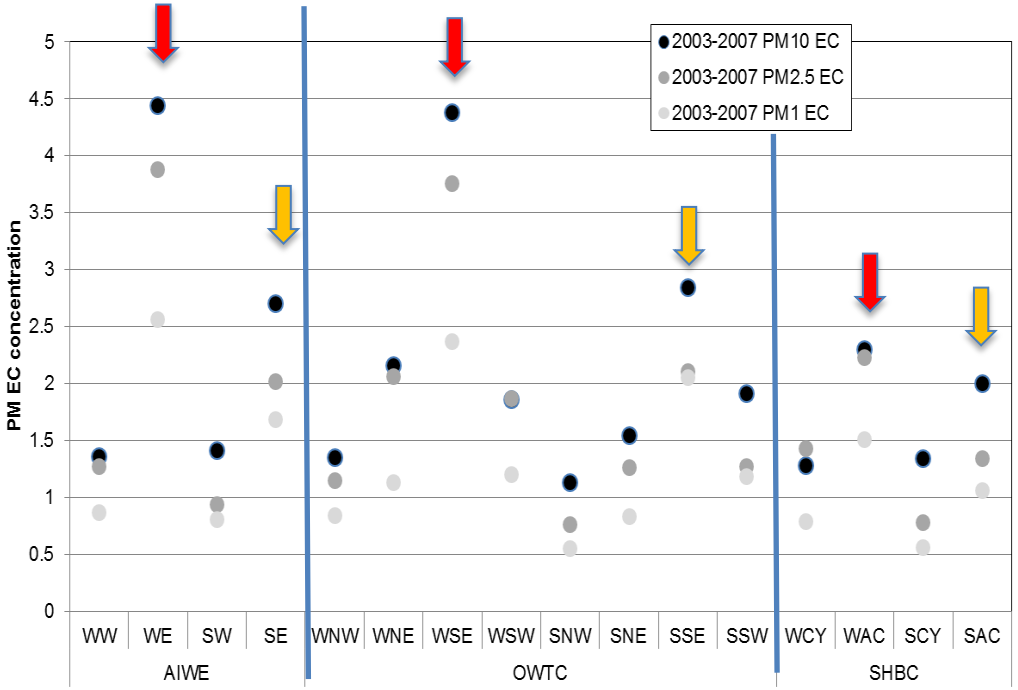


2013-16

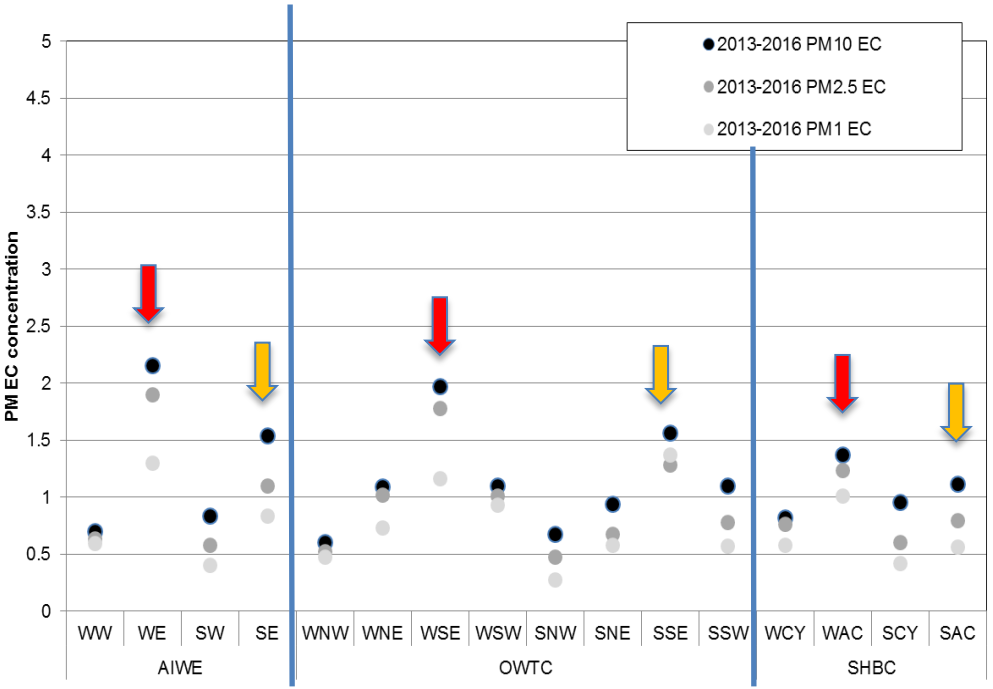
EC in PM_{10}, $PM_{2.5}$ and PM_1 for the Weather Type Classification Methods (2003-07 and 2013-16)

1993-98 EC not available

The highest mean mass concentrations for EC were found in **continental** air-masses in **Winter** and **Summer** its decline with time.



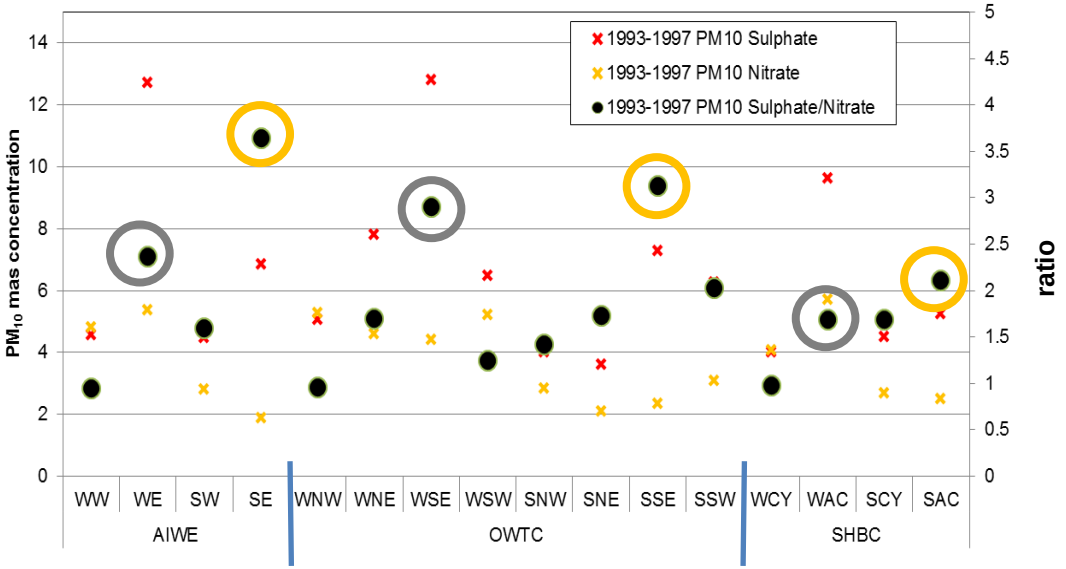
2003-07



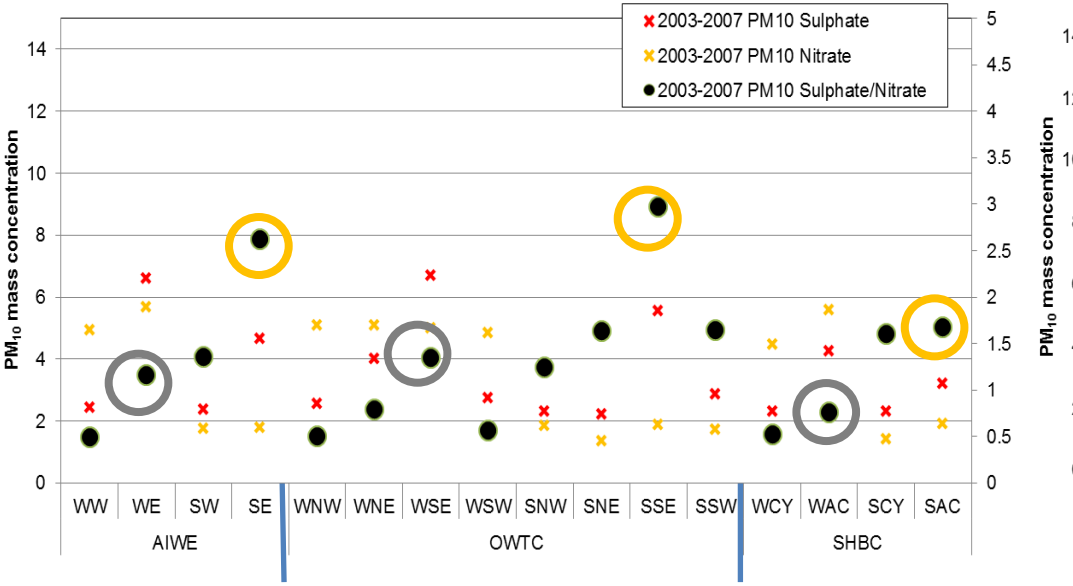
2013-16

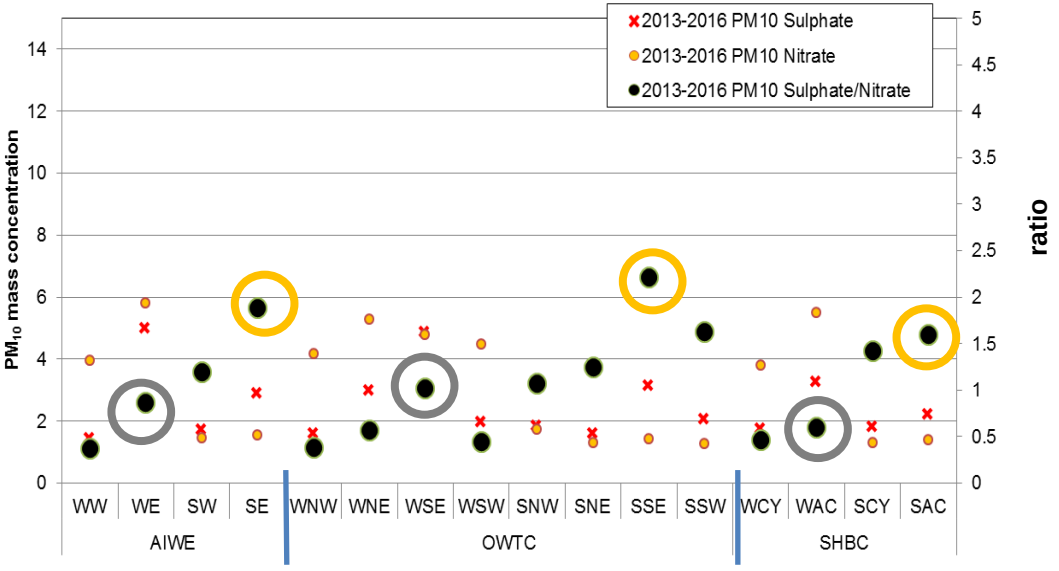
Sulphate/Nitrate ratio in PM_{10} – for the Weather Type Classification Methods (1993-98, 2003-07 and 2013-16)

1993-98



The highest mean Sulphate/Nitrate concentration ratios were found in **continental** air-masses in **Winter** ◯ and **Summer** ◯ .
The thermal volatility of Nitrate results in high summer values

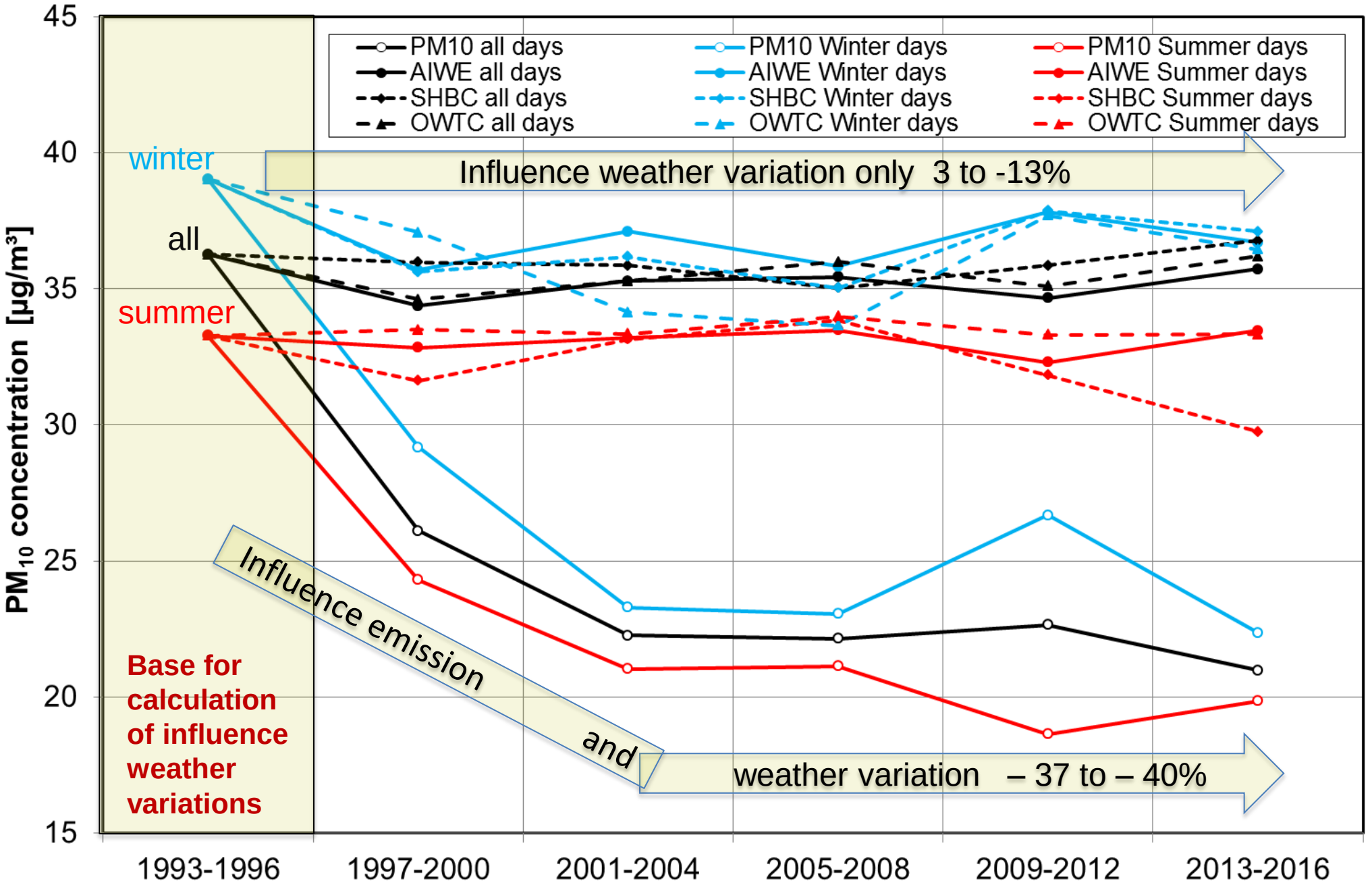




2003-07

2013-16

Trend in PM_{10} – influence of daily weather variation (11/1992 – 10/2016)



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Summary and outlook

The 24-year-comparison of the simplified air mass inflow West/East classification (AIWE), introduced for Melpitz site in 1994, with two weather type classifications from DWD, show comparable results. The AIWE-method has the benefit to use only 3 basic "weather types" instead of 40 (OWTC), respectively 30 (SHBC).

It can be estimated that the influence on the mean PM_{10} concentration, caused only by the distribution of days in weather classes is in the range of +3 to -13 % for each of the three weather type classifications in last 24 years.

The particle mass concentration PM_{10} decreases about – 40% since 1993 and remains constant in the last 16 years around 21.9 µg/m³ (± 7.5%).

The highest daily particle mass and EC-concentrations were found for days with more continental influenced long-range transported air masses in winter. The highest Sulphate/Nitrate ratio was found than in summer.

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Thank you for attention!

Latest news from Melpitz site

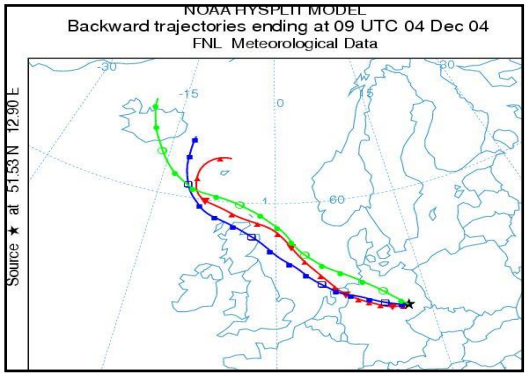
B. Stieger, G. Spindler, B.Fahlbusch, K. Müller, A. Grüner, L. Poulain, L. Thöni, E. Seitler, M. Wallasch, H. Hermann:
Measurements of PM_{10} ions and trace gases with the online system MARGA at the research station Melpitz in Germany – A five-year study.
Journal for Atmospheric Chemistry (Online first, 2017)
DOI 10.1007/s10874-017-9361-0 (Open Access)

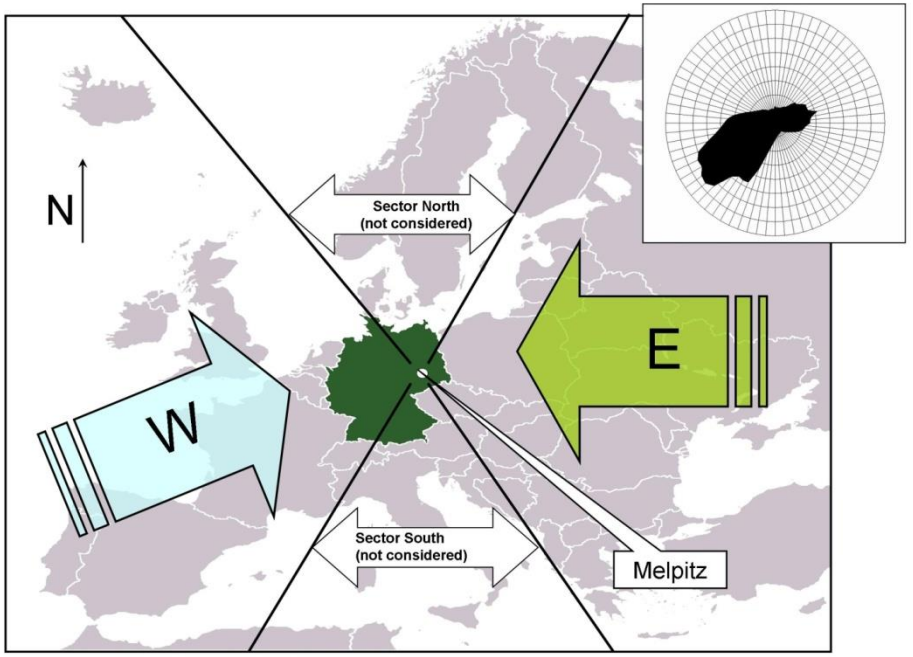
The authors acknowledge financial support of this study and deployment of the MARGA system by the German Federal Environment Agency (UBA) research foundation under contracts No: 351 01 031, 351 01 038, 351 01 093 and 351 01 070,
as well as the European Union within the projects
EUSAAR (European Supersites for Atmospheric Aerosol Research) under contract No: RII3-CT-2006-026140, and ACTRIS and ACTRIS-2 (Aerosol, Clouds, and Trace gases Research InfraStructure Network) under grant agreement No 262254 and 654109 (Horizon 2020).
For the laboratory analysis and the preparation of filters and solutions, we thank A. Dietze, A. Rödger and S. Fuchs. For the support especially in the field, we thank R. Rabe.

1. Simplified subjective categorization of measurement days for air mass inflow West/East (AIWE)

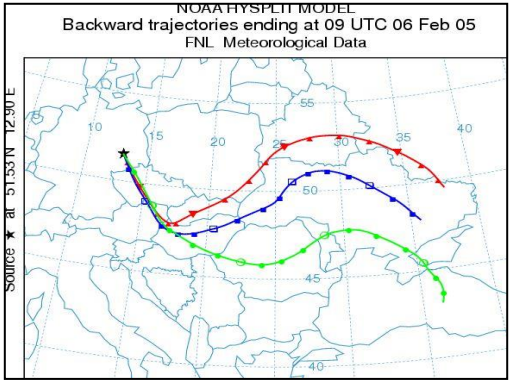
air mass inflow

Example sector **W**EST
210°-320°





Example sector **E**AST
35°-140°



96-hour backward trajectories for two times (10 and 18 o'clock CET), for 200, 500 und 1500 m over ground

source: http://www.arl.noaa.gov/ready/hysplit4.htm

additional differentiation

Winter: November – April
Summer: May - October

72.8 % of all days in **W**est and **E**ast (11/1992 until 10/2016)

WW	WE	WX
27.3	8.2	14.5%
SW	**SE**	**SX**
29.4	8.0	12.6%

6 categories

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2. Objective Weather Type Classification (OWTC) by German Weather Service (DWD)

Results of operational weather analysis and forecast system (12 UTC), meteorological indixes: $aaz_{950}z_{500}f$

aa: (wind) wind direction 5 classes XX, NE, SE, SW and NW

$z_{950}z_{500}$: (cyclonality) near surface (950 hPa) middle troposphere (500 hPa)

C index positive (cyclonality), A index negative (anticyclonality) 4 classes CC, CA, AC and AA

F: (humidity index) wet or dry 2 classes W and D

➡ Result 40 objective weather type classifications:

XXAAD, **NE**AAD, **SE**AAD, **SW**AAD, **NW**AAD, **XX**AAW, **NE**AAW, **SE**AAW, **SW**AAW, **NW**AAW,
XXACD, **NE**ACD, **SE**ACD, **SW**ACD, **NW**ACD, **XX**ACW, **NE**ACW, **SE**ACW, **SW**ACW, **NW**ACW,
XXCAD, **NE**CAD, **SE**CAD, **SW**CAD, **NW**CAD, **XX**CAW, **NE**CAW, **SE**CAW, **NW**CAW, **XX**CCD,
NECCD, **SE**CCD, **SW**CCD, **NW**CCD, **XX**CCW, **NE**CCW, **NE**CCW, **SE**CCW, **SW**CCW, **NW**CCW

➡ Summarizing in 5 wind direction classes and additional differentiation (%)

Winter: November – April
Summer: May - October

➡ **WNW** (16.8), **WNE** (4.8), **WSE** (3.0),
WSW (15.8), **WXX** (9.4),
SNW (13.4), **SNE** (3.1), **SSE** (2.7),
SSW (21.3), **SXX** (9.7)

80.8 % of all days are accessed for wind direction NW, NE, SE, SW
(11/1992 until 10/2016)

(for 17 days OWTC not considered, integrated here by XX)

3. Subjective determined Hess-Brezowsky Classification (SHBC) by German Weather Service (DWD)

A daily catalogue of subjectively-assessed *general weather situations* („Großwetterlagen“) (SGWL) for the greather European area was constructed by Hess and Brezowsky (*). The 29 SGWL are given for cyclonic, anticyclonic and mixed circulation refer to the local bias over Central Europe.

Abreviations for all SGWL and pooling in three classes

cyclonic: WA, WZ, WS, WW → **CY**

anticyclonic: NA, NZ, HNA, HMZ, HB, TRM, NEA, NEZ, HFA, HFZ, HNFA, HNFZ, SEA, SEZ, SA, SZ, TB, TRW, → **AC**

mixed circulation: SWA, SWZ, NWA, NWZ, HM, BM, TM → **MC**

not determined: U (only 48 days not considered, integrated here by MC)

6 categories

additional differentiation (%)

Winter: November – April

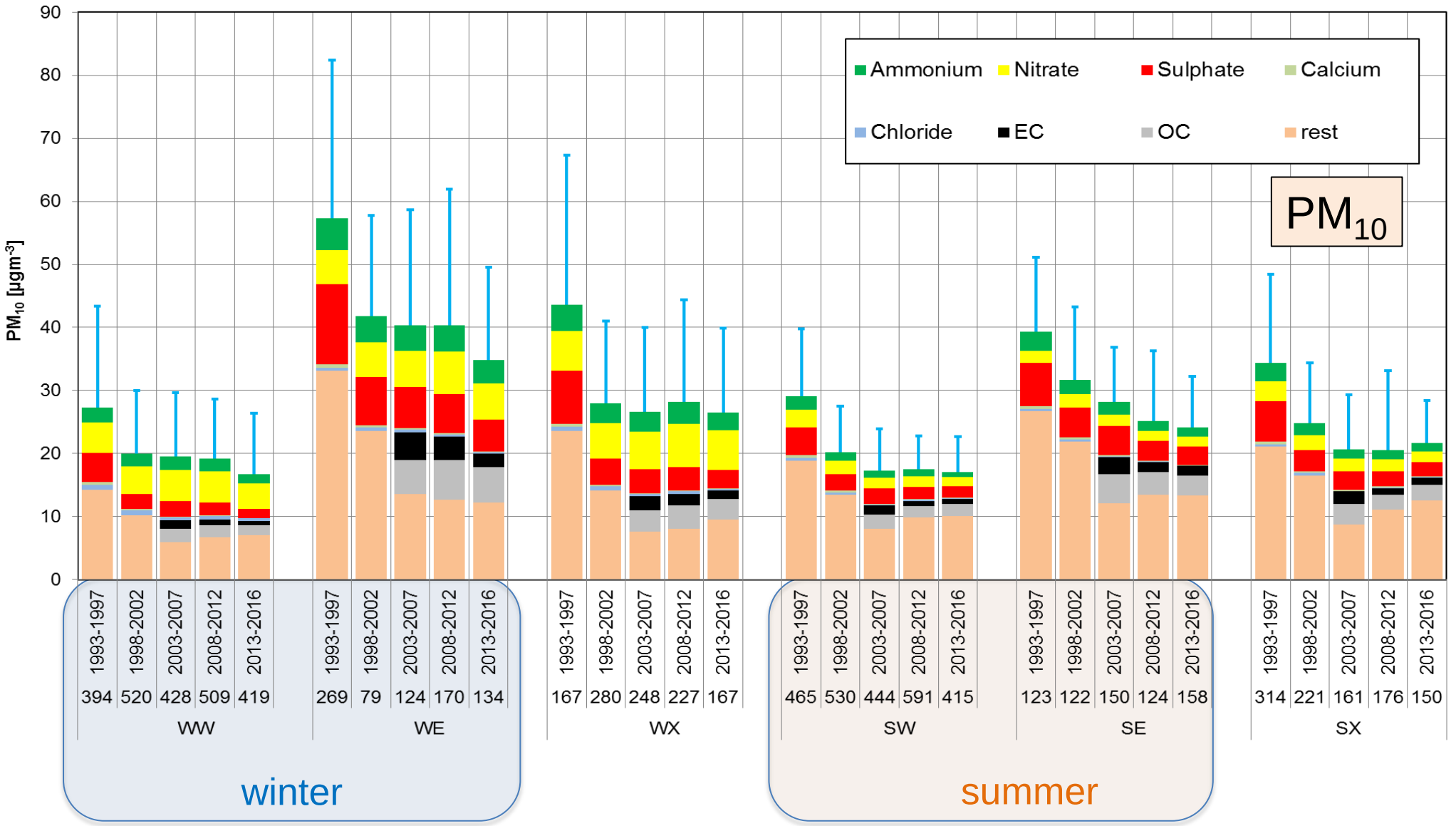
Summer: May – October

→ **WCY**(12.9), **WAC**(19.0), **WMC**(18.1), **SCY**(10.6), **SAC**(21.7), **SMC**(17.7)

64.1 % of all days are accessed for cyclonic and anticyclonic circulation (11/1992 until 10/2016)

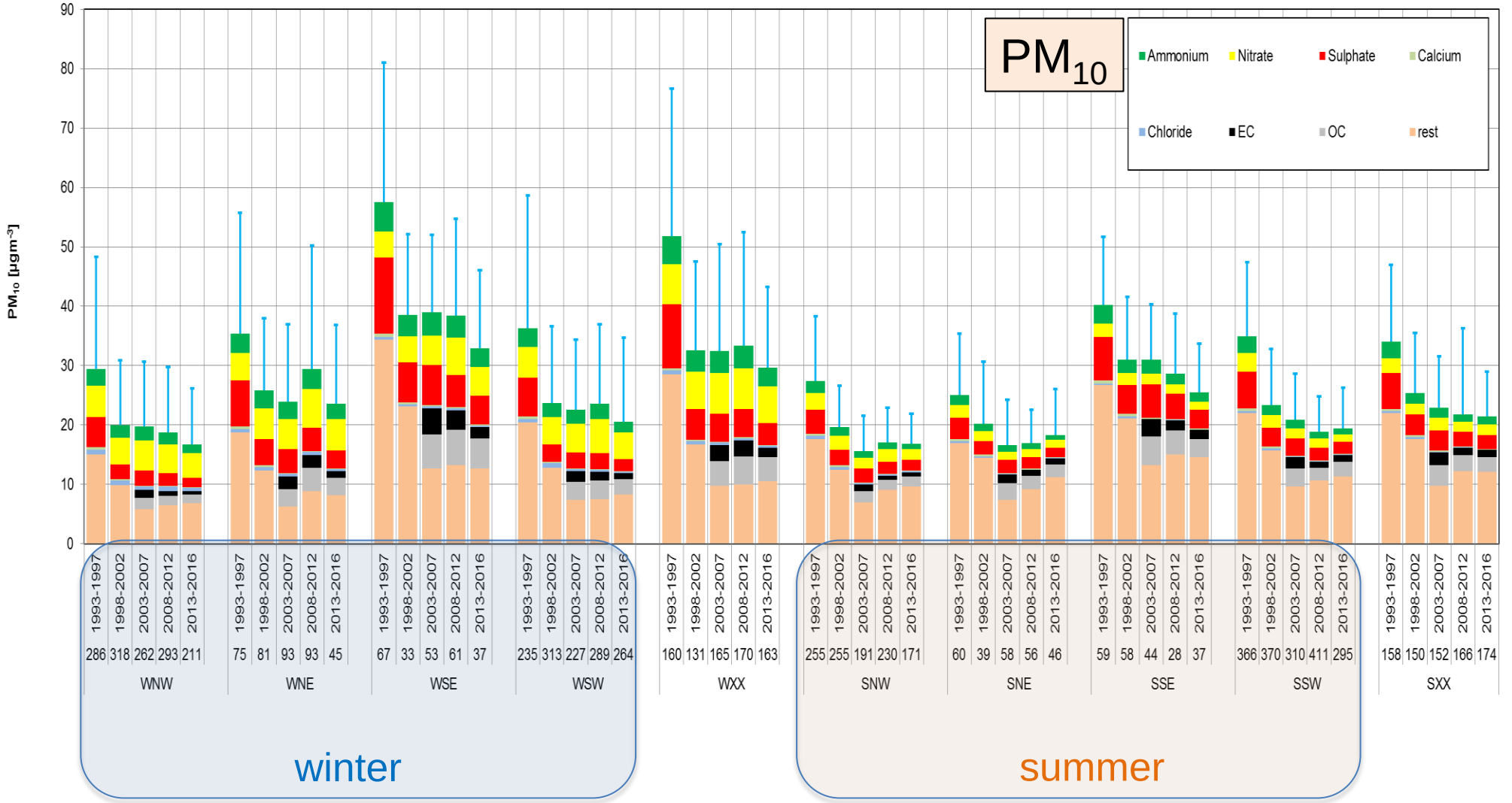
(*) Werner, P.C., Gerstengarbe, F.-W., 2010, PIK-Report 119, Katalog der Großwetterlagen Europas (1881-2009) nach Paul Hess und Helmut Brezowsky. 7. edition, 140 pages, https://www.pik-potsdam.de/research/publications/pikreports/.files/pr119.pdf

Air mass inflow West/East (AIWE) and PM_{10} concentration (11/1992 – 10/2016)



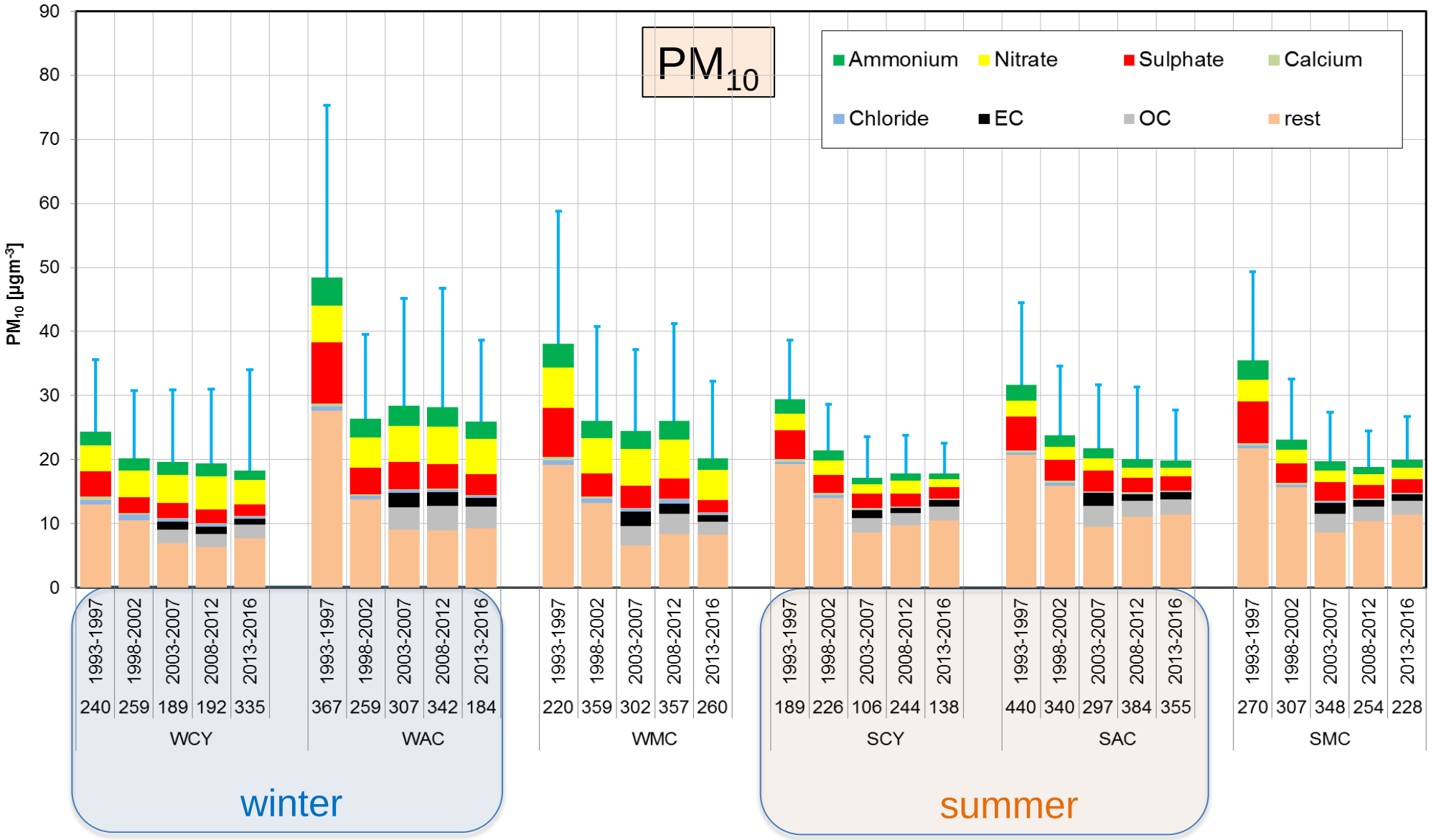
The error bars are the positive standard deviation of daily particle mass concentration means.

Objective Weather Type Classification (OWTC) and PM_{10} concentration (11/1992 – 10/2016)



The error bars are the positive standard deviation of daily particle mass concentration means.

Subjective Hess-Brezowsky Classification (SHBC) and PM_{10} concentration (11/1992 – 10/2016)



The error bars are the positive standard deviation of daily particle mass concentration means.

Trend in PM_{10} – influence of daily weather variation (11/1992 – 10/2016)

Bases for the estimation are the mean PM_{10} concentration (100%) for 1993-1996 (all day 36 µg/m³, winter 38 µg/m³ and summer 33 µg/m³).

The PM_{10} concentration is influenced by daily weather variations and emissions and decrease about

	(until 2004)	(until 2016)
all days	33 %	37 %
all winter days	40 %	40 %
all summer days	36 %	39 %

The influence of the daily weather variation only was estimated considering their different distribution for all, and for winter and summer days in the five year means in the range of:

all days	0 to -5% (AIWE)	0 to -5% (OWTC)	3 to -3% (SHBC)
all winter days	0 to -5%	0 to -13%	0 to -7%
all summer days	1 to -1%	1 to -1%	1 to 10%

TROPOS

Analysis of filter samples

Gravimetric mass

Weighing with micro-balances (Mettler Toledo, Switzerland).
(50±5)% relative humidity and temperature (20±1) °C (conditioning time 72 hours).

Water soluble ions

Determination by standard ion chromatography after an aqueous extraction.

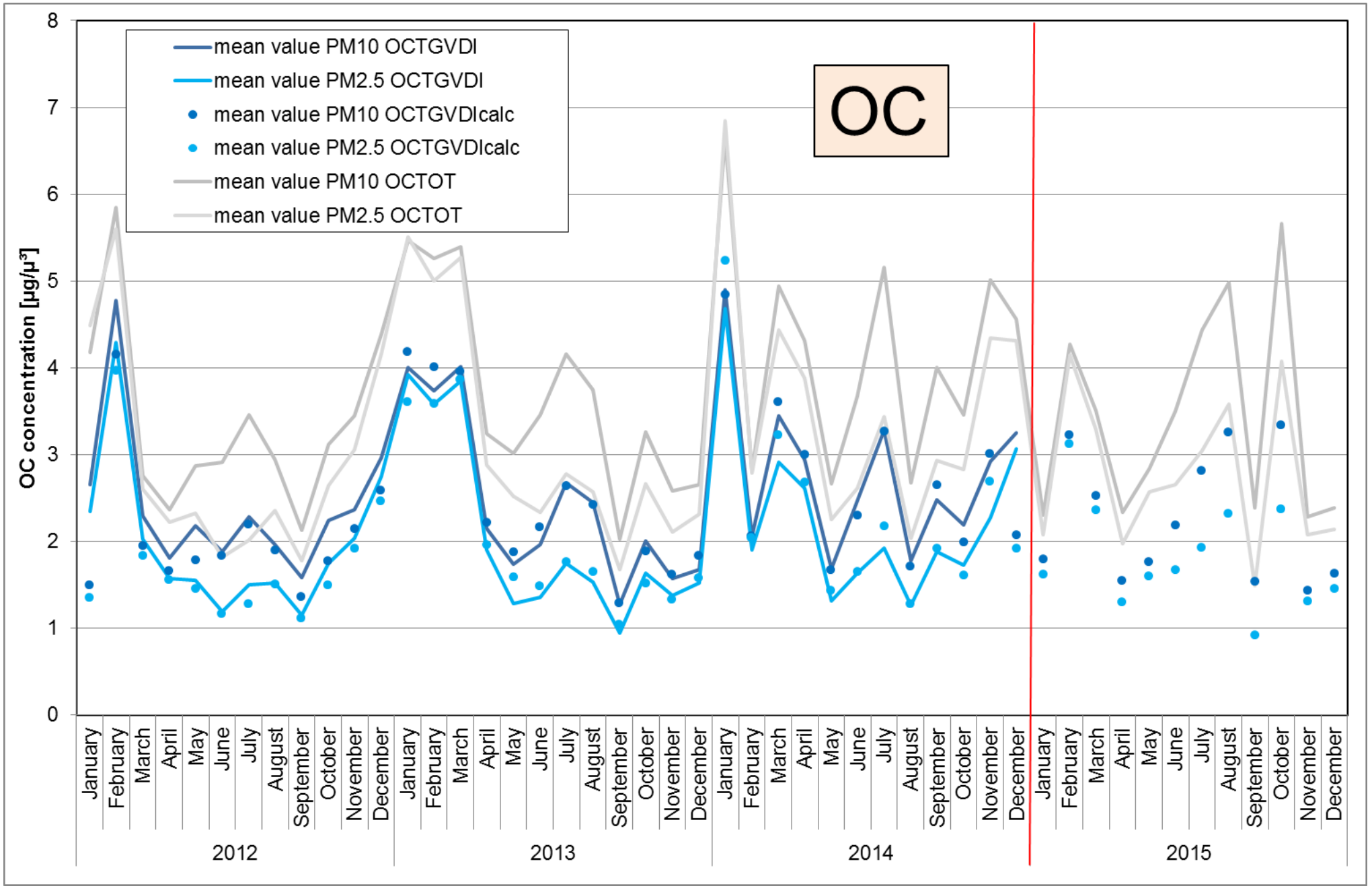
OC+EC=TC (2003-2014): Thermographic method (VDI 2465, page 2)

step: N_2-atmosphere 650 °C ⇒ organic carbon OC
step: O_2-atmosphere 650 °C ⇒ elemental carbon EC
Detection as CO_2 (IR) oxidation of C on a CuO-catalytic converter (850 °C)

Both methods for 2012, 13 and 14 used in parallel.
OC and EC for VDI method was estimated for 2015,16

Since 2012 thermo-graphic analysis, (Labanalyser Sunset Laboatory Inc., U.S.A.)
Temperature protocol EUSAAR2, Transmittance

OC, measured monthly means TOTEUSAAR2 and TGVDI in comparison to TGVDIcalc (monthly conversion equations)



The long-term dataset - PM High Volume (HV) Sampler, Quartz-filters

Sierra Andersen
Sampler 1000 l/min^{-1}

PM_{10} 11/1992-12/2002

Digitel DHA-80
Sampler 500 l/min^{-1}

PM_{10}, $PM_{2.5}$, PM_1 01/2003-12/2016

	11/1992	2002|2003	12/2016	8827 days
PM_{10}	daily	daily		94.5 %
$PM_{2.5}$	x	daily		96.6 %
PM_1	x	every 6th day		24.0 %