ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

RAPORTTEJA
RAPPORTER
REPORTS
2017:1

DEMONSTRATION OF THE EQUIVALENCE OF $PM_{2.5}$ AND PM_{10} MEASUREMENT METHODS IN KUOPIO 2014-2015

JARI WALDÉN
TUOMAS WALDÉN
SISKO LAURILA
HANNELE HAKOLA

WWW.FMI.FI

ISBN 978-952-336-010-5 (pdf)
ISSN 0782-6079

Helsinki 2017

FINNISH METEOROLOGICAL INSTITUTE

Series title, number and report code of publication
Reports 2017:1

Published by Finnish Meteorological Institute
(Erik Palménin aukio 1), P.O. Box 503
FIN-00101 Helsinki, Finland

Date 2017

Authors
Jari Waldén, Tuomas Waldén,
Sisko Laurila and Hannele Hakola

Name of project
$PM_{2.5}$ and PM_{10} tests for the demonstration of equivalence

Commissioned by
Ministry of the Environment

Title

Demonstration of the equivalence of $PM_{2.5}$ and PM_{10} measurement methods in Kuopio 2014-2015

Abstract

The Air Quality Directive, AQD, (2008/50/EC), set up the rules concerning the reference methods (RM) for the measurements of e.g. mass concentration of particulate matter in air. A member state can use any other method which it can demonstrate to display a consistent relationship with the reference method. In case of particulate matter the reference method is the gravimetric measurement method for the determination of the $PM_{2.5}$ and PM_{10}, mass concentration of suspended particulate matter. Demonstration weather a non-reference method is equivalent with the reference method for measurements of the concentration of particulate matter (PM) for the size classes of $PM_{2.5}$ and PM_{10}, i.e., particle sizes of less than 2.5 µm and 10 µm in aerodynamic diameter, respectively, was conducted in the city of Kuopio, Finland.

Altogether eight candidate methods (CM) i.e. measurement method for which the equivalence need to be demonstrated, participated in the equivalence studies: FH 62 I-R, Grimm model 180, MP101 CPM, Osiris, and SHARP model 5030, TEOM 1405, BAM 1020 and DustTrak 8535. The test program was constructed in accordance with the Guide for Demonstration of Equivalence of Ambient Air Monitoring Methods (GDE) by the European Commission. However, suitability test, which presumes that more than 20 % of the daily concentration values during the whole comparison study shall exceeds the upper assessment threshold (UAT) for annual limit value defined by the AQD, was not fulfilled for $PM_{2.5}$ measurements. This is a very typical situation in Finland. In case of PM_{10} comparison, the daily mass concentrations exceeded the UAT for more than 20 % of the measurement period to fulfill the requirement by the GDE. The calibration function against the RM has been presented for each CM as well as the results if non-compliance with criteria on any of the CMs has occurred. The results showed that DustTrak 8535 failed to meet the criteria for equivalence for fixed measurements of $PM_{2.5}$ and PM_{10}. Osiris fulfilled the criteria for PM_{10} measurements, but failed to meet the criteria for $PM_{2.5}$ measurements. All other CMs, FH 62 I-R, Grimm model 180, MP101 CPM, SHARP model 5030, TEOM 1405 and BAM 1020 fulfilled the criteria for $PM_{2.5}$ and for PM_{10} measurements.

Publishing unit
Air Quality

Classification (UDK)
502.3:613.15, 681.2

Keywords
Air Quality, Instrumentation

ISSN and series title
0782-6079 Raportteja-Raporter-Reports

ISBN
978-952-336-010-5 (pdf)

Language
English

Sold by
Finnish Meteorological Institute
P.O. Box 503, FIN-00101 Helsinki
Finland

Pages 134 Price

Notes

Julkaisun sarja, numero ja raporttikoodi
Raportteja 2017:1
Julkaisija Ilmatieteen laitos, (Erik Palménin aukio 1)
PL 503, 00101 Helsinki
Julkaisuaika
2017

Tekijä(t)
Jari Waldén, Tuomas Waldén,
Sisko Laurila ja Hannele Hakola

Projektin nimi
$PM_{2.5}$- ja PM_{10}-vertailumittaukset
ekvivalenttisuuden osoittamiseksi

Toimeksiantaja
Ympäristöministeriö

Nimike

$PM_{2.5}$- ja PM_{10}-mittausmenetelmien yhdenmukaisuuden osoittaminen vertailumenetelmää vastaan Kuopiossa 2014–2015

Tiivistelmä

Euroopan Yhteisön CAFÉ-direktiivin (2008/50/EY) määrittää mm. hiukkasmittausten vertailumenetelmän, mikä perustuu hiukkasmassan gravimetriseen määritykseen. Jäsenmaa voi käyttää muuta menetelmää vertailumenetelmän sijasta, mikäli se voi osoittaa, että tulokset ovat yhteneviä vertailumenetelmän antamien tulosten kanssa. Tällaisella menetelmällä saatuja tuloksia on tarvittaessa korjattava, jotta saataisiin vertailumenetelmää käyttämällä saatavia tuloksia vastaavat tulokset. Hiukkasmittausten osalta vertailumenetelmä $PM_{2.5}$ ja PM_{10} massapitoisuuden määrittämiseksi ulkoilmassa perustuu gravimetriseen määritysmenetelmään. Tässä tutkimuksessa testattiin eräiden jatkuvatoimisten hiukkasmittalaitteiden yhdenvertaisuutta vertailumenetelmää vastaan noudattaen komission ohjetta. Vertailumittaukset tehtiin Kuopiossa ja ne käsittivät hiukkasten aerodynaamiselta halkaisijaltaan olevat alle 2.5 µm:n ja alle 10 µm:n kokoiset hiukkasmittaukset.

Vertailuun osallistuivat kaikkiaan kahdeksan eri jatkuvatoimista hiukkasanalysaattorimallia: BAM 1020, DustTrak 8535, FH 62 I-R, Grimm 180, MP101 CPM, Osiris, SHARP 5030 ja TEOM 1405. Vertailumittausohjelma toteutettiin komission ohjeen mukaisesti. Ohje määrittelee mm. pitoisuustasoista niin, että 20 % havainnoista tulee ylittää alimman arviointikynnykset (UAT) sekä $PM_{2.5}$ että PM_{10} massapitoisuuksille. Havaintoaineistosta osoittautui, että $PM_{2.5}$ massapitoisuudet eivät ylittäneet sille asetettua UAT arvoa, 17 µg/m^3, yli asetetun kriteerin, vaan tästä jäätiin selvästi alle. Verrattaessa Suomessa mitattuja $PM_{2.5}$ pitoisuuksia, voidaan todeta, että hyvin harvoin mittauksissa ylitetään UAT-arvo $PM_{2.5}$ pitoisuuksissa. PM_{10} pitoisuuksissa sen sijaan ylempi arviointikynnys, 30 µg/m^3, ylitettiin useammin kuin vaadittava määrä. Vertailumittaustulokset analysoitiin komission ohjeen mukaan ja sen perusteella esitetään jokaiselle vertailtavalle hiukkasanalysaattorille kalibrointikertoimet sekä $PM_{2.5}$- että PM_{10}-mittauksille. Raportissa osoitetaan myös kaikki poikkeamat, mitä esiintyi sallituista kriteereistä. Tulosten perusteella voidaan todeta, että yksi vertailtava analysaattori, DustTrak 8535, ei täyttänyt vaadittavia kriteerejä sekä $PM_{2.5}$- että PM_{10}-mittauksille. Osiris täytti vaatimukset PM_{10}-mittauksille, mutta ei $PM_{2.5}$-mittauksille. Sen sijaan kaikki muut testatut hiukkasanalysaattorit, FH 62 I-R, Grimm 180, MP101 CPM, SHARP 5030, TEOM 1405 ja BAM 1020 täyttivät vertailumenetelmälle asetetut vaatimukset sekä $PM_{2.5}$- että PM_{10}-mittauksille.

Julkaisijayksikkö
Ilmanlatu

Luokitus (UDC) 502.3:613.15, 681.2
Asiasanat Ilmanlaatu, mittalaitteet

ISSN ja avainnimike
1796–1203 Raportteja-Raporter-Reports

ISBN 978-952-336-010-5 (pdf)
Kieli Englanti

Myynti
Ilmatieteen laitos
PL 503, 00101 Helsinki
Sivumäärä 134
Hinta
Lisätietoja

Contents

List of abbreviations

AQD	Air Quality Directive
CM	Candidate Method
DQO	Data Quality Objectives
EC	European Commission
EU	European Union
EMEP	Programme for Monitoring and Evaluation of long range transmission of air Pollutants in Europe
FMI	Finnish Meteorological Institute
GDE	Guidance for Demonstration of Equivalence
HSY	Helsinki Region Environmental Services Authority
LV	Limit Value
MS	Member States
PM	Particulate Matter
PTFE	Polytetrafluoroethylene
RM	Reference Method
TSP	Total Suspended Particles
UAT	Upper Assessment Threshold
WG	Working Group

1. Introduction

The European Commission (EC) has the air quality on high priority in European policy. Mostly the pollutants have health effects on human beings and can damage vegetation. To prevent the harmful effects of pollutants in humans and vegetation the European Commission has prepared directives to define the limit values for the maximum concentrations of certain pollutants in ambient air. The new Commission Directive 2015/1480/EC (CD) amend some of the annexes in the Air Quality Directive 2008/50/EC (AQD), but also defined the responsible authorities and their tasks, the limit values and data quality objectives (DQO) for specific pollutants as well as updated the reference methods for the measurements. The national authorities also appoint a National Reference Laboratory for specific tasks amongst, i.e. the coordination of the appropriate use of the reference methods and the demonstration of equivalence of non-reference methods. The member states (MS) can, however, use another measurement method if it can be shown to give results equivalent with the reference method. To harmonize the process of demonstrating the equivalency of a candidate method (CM) with the reference method, the EC working group on Guidance for the Demonstration of Equivalence prepared a guide. As a result of the working group, the test criteria set out in the EC Guidance for the Demonstration of Equivalence of Ambient Air Monitoring Methods (GDE) was published in 2005 and reviewed in 2009. Throughout the report, the latest version of the GDE i.e. from the year 2010 is used. The meaning of the term 'equivalent method' was defined in the GDE as '*An equivalent method to the reference method for the measurement of a specified air pollutant, is a method meeting the data quality objectives for fixed measurements specified in the relevant air quality directive'*. This definition is used also in this report.

Member states have conducted the equivalence tests especially with the analyzers of automated particulate matter (Harrison et al. 2006, Beijk et al. 2007, de Jonge 2008, Bertrand, et al. 2009) over the past years. Additionally testing laboratories, like Tüv Rheinland in Germany, have completed a great number of tests for demonstrating equivalency of the automated PM analyzers (www.qal1.de). Similarly, the UK testing scheme for air quality measurements (MCERT) have conducted and published equivalency tests for the PM analyzers (www.sira.uk).

This report provides test results of the comparisons of the automated candidate methods against the reference methods for $PM_{2.5}$ and for PM_{10} measurements. This is the second trial for demonstration of equivalency for automated PM analyzers in Finland. The first was conducted in Helsinki in 2007 - 2008 (Walden et al., 2010). The comparisons as well as the analysis of the comparison results were conducted according to the GDE. The candidate methods tested in this comparison were those used or planned to be used in the local air quality networks in Finland.

2. PM equivalence procedure

2.1 Requirements of Directive 2008/50/EC and 2015/1480/EU

The Air Quality Directive 2008/50/EC (AQD) states that member states shall apply the reference measurement methods for measurements of the atmospheric pollutants for which limit or target values are defined in the Directive. Other measurement methods may be used, subject to the conditions also set out in the Directive. The reference measurement method for the sampling and measurement of mass concentration of PM_{10} as well as $PM_{2.5}$ is gravimetric and is prescribed in European standard (European Norm, EN) EN 12341 (EN 12341, 2014) prepared by the European Committee for Standardization (CEN). The Directive defines that PM_{10} and $PM_{2.5}$ means particulate matter that passes through a size-selective inlet with 50 % efficiency at cut-off size of 10 µm and 2.5 µm as aerodynamic diameter, respectively. In Figure 2.1 the sampling efficiency for the PM_{10} sampling inlet is shown (Kaminski and Kuhlbusch, 2010). From the figure one can see that the sampling efficiency for 10 µm particles is 50 % reaching zero at a size of 20 µm. The standard prescribes the measurement method including the inlet design criteria for both of the size classes as well as the storage and weighing procedures for the filters. The approved filter materials for the collection of the PM fraction are also defined. In addition to the reference methods, the AQD lays down that the mass concentration for PM results shall be referred to the prevailing ambient conditions in terms of temperature and atmospheric pressure. The DQO defined for the PM measurements in the AQD are listed in Table 2.1.

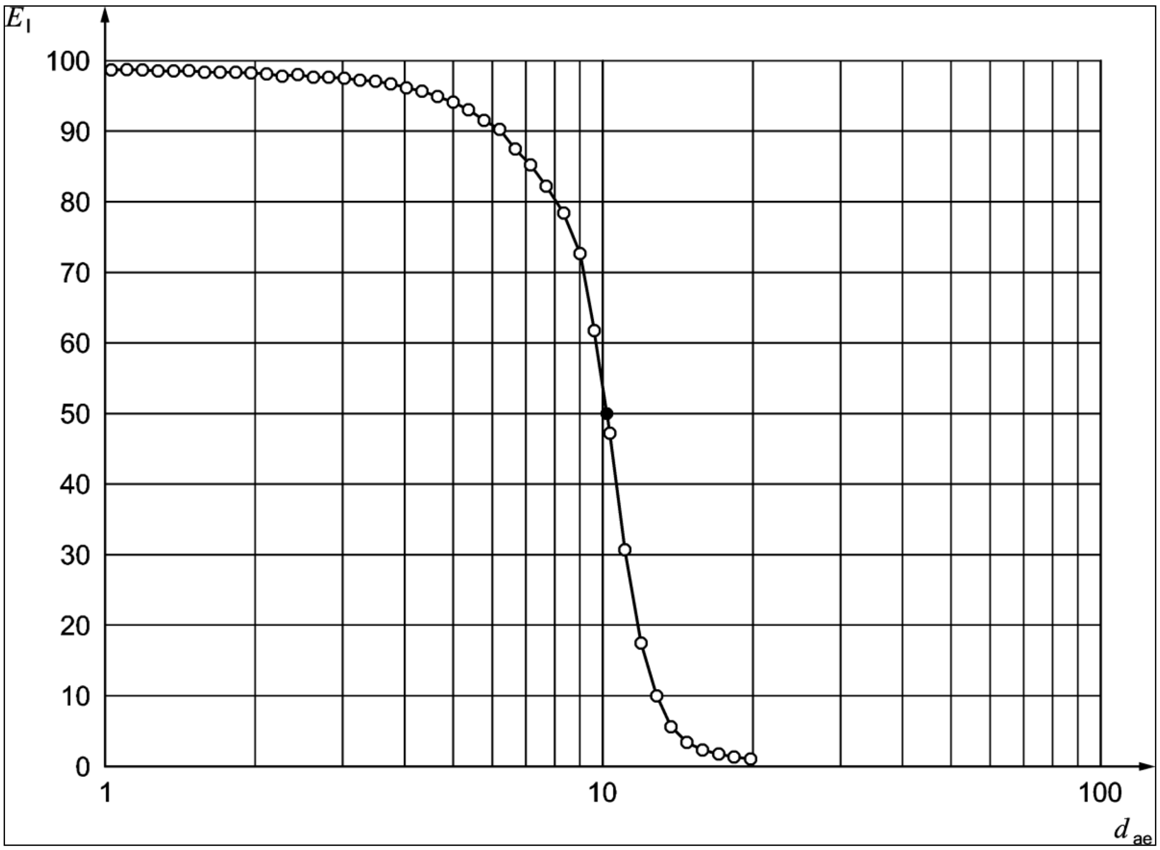

Figure 2.1: The sampling efficiency of the PM_{10} sampling inlet.

Table 2.1. The Data Quality Objective for the $PM_{2.5}$ and PM_{10} measurements for fixed and indicative measurements according to the AQD.

	$PM_{2.5}$ and PM_{10}
Fixed measurements	
uncertainty [1]	25 %
minimum data capture	90 %
Indicative measurements	
uncertainty [1]	50 %
minimum data capture	90 %
minimum time coverage	14 % [2]

[1] Describes the relative expanded measurement uncertainty at the 95 % confidence level.

[2] One measurement a week at random, evenly distributed over the year, or eight weeks evenly distributed over the year.

Beside the reference method for measurements of mass concentration of PM_{10} and $PM_{2.5}$, automated measurement methods have been manufactured and used for the PM measurements. The automated methods can provide data at much shorter intervals, e.g. from tens of seconds up to hourly values, than the reference method and can be used to trace sudden changes in the PM concentrations in the air and in the calculation of air quality indexes.

In 2002, EC launched a working group on Guidance for the Demonstration of Equivalence. After couple of years of work, the WG completed its work in 2005 with a document *Guide to the Demonstration of Equivalence of Ambient Air Monitoring Methods*, *GDE*. To facilitate the use of the GDE for the demonstration of equivalence of the candidate methods (CM) against the reference method (RM) for PM monitoring, an Excel macro was made available on the Commission web page (http://ec.europa.eu/environment/air/quality/legislation/assessment.htm,). The macro (R. Beijk, 2011) allows the user to test of the equivalency for input pairs of data values of the CM and the RM. The GDE document was revised in 2008 and was implemented into the Directive 2008/50/EC. Some editorial corrections were made to the version 2010, which is the present version and is referred to here.

2.2 The reference method

The reference sampler used during the PM equivalence tests in Kuopio (PM_{10} and $PM_{2.5}$) was a sequential type sampler SEQ47/50 by Sven Leckel, Ingenieurbüro GmbH, Germany. Two identical units of the samplers were used both for the PM_{10} and the $PM_{2.5}$ tests. The layout of the reference sampler is shown in Figure 2.2. The size classification inlet followed the designing criteria of the EN 12341 and is shown in Figure 2.3. By switching the jets inside, the inlet can be used for PM_{10} and $PM_{2.5}$ measurements. The sampler is equipped with a heater to keep the temperature above the dew point to prevent sample filters from freezing at winter conditions. In addition, cooled sample tube by sheath flow and enclosed sample filters within the filter cartridge prevent the volatilization of semi-volatilized compounds such as sulphate, ammonia and nitrate.

The filter types used in the tests were polytetrafluoroethylene (PTFE) filters, Millipore Fluoropore FSLW047 # 3 µm, by Millipore.

Figure 2.2: The layout of the reference method, the flow controlling units by MCZ and the PM inlets by Digitel, used for the PM_{10} and the $PM_{2.5}$ equivalence tests.

Figure 2.3: The sampling inlet of the sequential sampler SEQ47/50.

2.3 Candidate methods

The following candidate instruments, manufacturer and the acronym of the instrument used in this report (in parenthesis) took part in the PM equivalence tests:

1. FH 62 I-R by Thermo Fisher Scientific, USA (FH 62 I-R);
2. Grimm Environmental Dust Monitor, model 180, by GRIMM Aerosol Technik GmbH & Co. Member of Durag Group, Germany (Grimm 180);
3. MP101 CPM, by Environnement SA, France (MP101_CPM)
4. Osiris, by Turnkey Instruments Ltd, England (Osiris);

5. Synchronized Hybrid Ambient Real-time Particulate Monitor, model 5030 by Thermo Fisher Scientific, USA (SHARP);
6. Tapered element oscillating microbalance, TEOM 1405 by Thermo Fisher Scientific, USA (TEOM 1405);
7. BAM-1020 Continuous Particle Monitor, Met One Instruments, Inc. (BAM);
8. DustTrak Aerosol monitor, model 8535, TSI Incorporated, USA (DustTrak).

Short descriptions of the CMs are given below. The set-up and the sample equipment of each of the CMs are described. The type of sampling inlets, sampling flow rates, sampling period and the condition of the sample tube (heated/not heated) are reported. As a general rule, correction coefficients or any other factors installed in the operational software, were checked and recorded. Also the version of software were checked and recorded. For parallel CMs the correction coefficients and factors were set to be equal. This means that the CMs were tested against the RM with the same basic measurement signal, sampling equipment and sampling tube conditions during the test campaigns. If deviations in the set-up of the CMs from the equivalence tests occur in routine use, the test results may not be valid. Examples of such deviations are deviations from the sampling tube temperature, a different sample flow rate, or a different sample inlet. In these circumstances, more evidence is needed to demonstrate the validity of the test results. If the deviation of the CM from the test condition is associated with the measurement signal and can be transformed to the test conditions mathematically, the test results obtained in the equivalence tests are then valid. The manufacturer is responsible for informing on any changes made in the instruments, which may cause a significant change in the performance of the instrument. If the manufacturer apply the ISO EN 15267 (EN 15267 1-2, 2009) in the production the information on the changes made to instrument is mandatory. In other case it is voluntary. A change of materials can also have influence on the performance of the instrument, and the customers should be informed on this. An example of this is the change of filter material with material, which is more resistant for the humidity effect.

FH 62 I-R

The ESM FH 62 I-R monitor by Thermo Fisher, USA, shown in Figure 2.4, uses the technique of β-attenuation (Kr-85 source). The attenuation of β-rays by a filter is directly related to the amount of mass on the filter. The air sample is collected on the pure spot of the filter tape and is remains at the measurement/sample point until it is full loaded or after 24 hour sampling after which the filter tape rotates to bring a new pure spot on the measurement/sample point. The analysis of the sample, however, takes place cumulatively over the 24 h. To avoid condensation of water on the filter, the sampling tube is heated (35 °C). This process not only leads to the loss of water, but also to the loss of certain semi-volatile compounds such as ammonium nitrate. By changing the sample inlet, the device is capable of making measurements of PM_{10} and $PM_{2.5}$ at a sample flow of 1 m^3/h. The sample inlet was one of the commercial types designed according to the EN-standards for $PM_{2.5}$ and PM_{10}. The measurement range for normal operation is from 0 $\mu g/m^3$ to 5000 $\mu g/m^3$. The manufacturer provides a calibration kit, i.e., a zero plate and a plate of known amount of mass concentration on a film foil to calibrate the instrument. The calibration kit was used for calibration of the instrument during the equivalence test. The manufacturer of the instrument installed a correction factor with a default value of 1.3 in the operational software of the instrument to correct the measurement signal according to the guideline by the EC (EC WG on PM, 2001). In these tests, the correction factor was set to 1.0 according to the policy mentioned in the previous chapter.

Figure 2.4. FH 62 I-R monitor.

Grimm Environmental Dust Monitor, model 180

The Grimm ambient dust monitor 180 is a stationary continuous fine dust measuring system for the simultaneous and continuous measurement of PM_{10}, $PM_{2.5}$ and PM_1. The Grimm 180, shown in Figure 2.5, does not have $PM_{2.5}$ or PM_{10} sampling heads according to EN-standards. The sample inlet of the Grimm is the manufacturer's own design, but it has been tested against the PM_{10} reference method according to EN 12341 (LUBW, 2005). The sample flow rate of the Grimm was 1.2 l/min as stated by the manual and the sampling tube was inside the shield tube at ambient temperature. The concentration range for dust particles is from 0.1 to 1500 µg/m^3. The instrument uses an optical technique, based on light scattering, to divide particles into different sizes in diameter. The value of the refraction index of the particles, i.e., how much the velocity of light is reduced due to the reflection from the surface of the particles, has been programmed into the software. Specific algorithms are used to transfer the number of particles of certain size into mass.

The calculated cut-off point curves are then applied to define the mass concentration for PM_1, $PM_{2.5}$ and PM_{10}. The sample air passes through an isothermal air drying system-during which moisture is extracted via a Nafion tube. This reduces the possibility of nucleonic condensation and therefore artificial growth/weight. The pump of the Nafion dryer starts at relative humidity of 50 % reducing the relative humidity down to 35 %.

Figure 2.5. Grimm Environmental Dust Monitor, model 180.

MP101 CPM

The MP101 CPM, shown in Figure 2.6, measures particulate concentration based on the technique of β-attenuation by measuring the amount of radiation a sample absorbs when exposed to low-energy β-rays (C-14 source). For continuous and simultaneous measurement of fine dust the CM was equipped with a CPM module using the optical measurement technology. By changing the sample inlet, the device is capable of measurements of PM_{10} and $PM_{2.5}$ at a sample flow of 1 m^3/h. The sample inlets for $PM_{2.5}$ and PM_{10} were designed according to the EN-standards by the manufacturer. The sampling tube is equipped with shielded flow to avoid condensation in the sample air when entering the analyzer. The measurement ranges of the instrument are selectable up to 10 000 $\mu g/m^3$.

The sampling time was set to 1 h in the operational software of the instrument by the manufacturer.

Figure 2.6: Environnement MP101 CPM monitor.

Osiris

The Osiris is one of Turnkey's families of direct-reading airborne particle monitors, which can be used as a portable instrument or deployed in a semi-permanent installation. The Osiris, shown in Figure 2.7, indicates continuously the concentration of total suspended particles (TSP), PM_{10}, $PM_{2.5}$ and PM_1 at a range of up to 6000 $\mu g/m^3$ based on an optical method. The sample flow rate of the Osiris is 0.6 l/min. The sample tube was heated (35 °C) to avoid condensation. The sample inlet was designed by the manufacturer; no test report for the sample inlet against the reference method was available.

Figure 2.7. Osiris optical dust monitor

SHARP, model 5030

The SHARP monitor by Thermo Fisher combines light-scattering photometry and beta radiation attenuation (C-14 source) in one instrument, shown in Figure 2.8. The instrument combines nephelometry and the beta attenuation method to provide a continuous reading of the PM concentration. The sampling strategy is the same as in FH 62 I-R. The output signals can be selected to provide the dust signal, β-signal and optical signal. The C-dust signal is the optical signal corrected with the β-signal providing the fast response signal. The β-signal represents beta radiation attenuation method with a time interval of an hour. The optical signal is a direct signal from the nephelometer but is uncalibrated. For normal use, the C-dust signal is recommended. Control of relative humidity and frequent filter changes eliminate water vapor without loss of volatile organic compounds. By changing the sample inlet, the device is capable of measurements of PM_{10} and $PM_{2.5}$ at a sample flow of 1 m^3/h. The commercial sample inlet was used during the tests. The concentration ranges can be from 0 to 1000 $\mu g/m^3$ or from 0 to 10 000 $\mu g/m^3$. For calibration of the instrument the same calibration kit as in the FH 62 I-R was used. To avoid condensation, the sample tube was heated (35 °C).

Figure 2.8. Synchronized Hybrid Ambient Real-time Particulate Monitor, SHARP, model 5030

TEOM 1405

The TEOM 1405, shown in Figure 2.9, uses the tapered element oscillating microbalance technique to measure the concentration of the particulate matter in the air. It is a direct mass measurement technique on a filter with real-time data output. The sample filter need to be changed according to the loading percentile of the filter as indicated by the instrument or at regular intervals. By changing the sample inlet, the device is capable of making measurements of PM_{10} and $PM_{2.5}$ at a sample flow of 1 m^3/h. The sample inlet provided by the manufacturer was used during the equivalence measurements. In the case of the $PM_{2.5}$ test, the sharp cut cyclone (cut to size for $PM_{2.5}$) was installed in the sampling tube to remove particles larger than $PM_{2.5}$. The measurement concentration range of the particles for the TEOM 1405 can be up to 5 g/m^3. To avoid condensation, the sample tube was heated (50 °C). The correction equation used in the software of the device by the manufacturer was of the form: $y = a + b \cdot C$, where $a = 3\ \mu g/m^3$, $b = 1.03$ and C is the measurement signal.

Figure 2.9: Thermo Scientific Ambient Particulate Monitor, TEOM 1405

BAM 1020

The BAM 1020 particulate monitor shown in Figure 2.10 uses the beta attenuation method. The mass of the sample collected on the filter tape is measured by detecting the attenuation of β-rays from a radioactive source of C-14. The measurement cycle consist of the measurement of the β-count rate through a clean filter spot, sampling interval and the measurement of the β-count rate through sampled filter spot. The analysis of the β-count rate takes 8 min and the removal of the filter tape between the analysis and sampling points takes 1 – 2 min allowing a sampling time of 42 min for the whole measurement cycle of

60 min. However, with the tested CMs the Estonian Environmental Research Centre (EERC) selected the measurement cycle as 180 min, which is the practice in Estonia. The main reason for the practice by the EERC was to decrease the running costs of the instrument by extending the duration of the filter tape from the normal 60 days up to 180 days. This practice was agreed with the FMI and EERC at the beginning of the comparison. The sampling system consists of sampling tube, sampling inlet for PM_{10} and a sharp cut cyclone for $PM_{2.5}$ sampling. A smart inlet heater was installed in the sampling tube to control the maximum relative humidity at the filter tape (45 % as factory setting). There are some additional instructions by the manufacturer to clean the nozzle and vane of fibers released from the filter tape.

Figure 2.10: BAM 1020 Ambient Beta Gauge Particulate Monitor

DustTrak 8535

DustTrak 8535 follows the principles of light scattering from dust particles by laser light. The instruments were sent to comparison tests without a sample heater and heat shield assembly. The instrument is presented in Figure 2.11. The data was stored on the mass memory of the instrument, collected every two weeks through a USB memory stick and stored on the database with the other CMs at the FMI.

Figure 2.11: DustTrak 8535.

In Table 2.2 the participating CMs are presented including the manufacturer or their representative organization, the measurement methods and type of sampling inlets and the temperature of the sampling tube for both the $PM_{2.5}$ and for PM_{10} comparisons. The software version used for each of the CMs is presented in Annex A1.

Table 2.2: List of CMs, representative organizations/manufacturers, measurement methods, type of sampling inlets, and sampling tube temperature for the $PM_{2.5}$ and PM_{10} comparisons. The last column indicates the field campaigns for which the $PM_{2.5}$ and PM_{10} comparison took place (T = Tasavallankatu and S = Savilahdentie).

Instruments	Manufacturer / Representative / Instrument provider	Method	PM10/PM2.5 inlet	Sample tube	Field campaign (T/S)
REFERENCE SAMPLER	Leckel SEQ 47/50	Sequential sampler	Leckel	Ambient	T/S
Environnement MP-101+CPM	ENVIRONNEMENT SA (France)	β-attenuation + optical	Environment EN	Shield tube, ambient temp	T/S
GRIMM-180	Finnish Meteorological Institute	Optical (light scattering)	Grimm	Shield tube, nafion drier	T/S
SHARP 5030	Finnish Meteorological Institute	Light scattering +β-attenuation	Digitel /EN	Heated 35 ºC	T/S
FH-62-IR	Finnish Meteorological Institute	β-attenuation	Digitel /EN	Heated 35 ºC	T/S
BAM 1020	Estonian Environmental Research Centre (Estonia)	β-attenuation	US-EPA	Heated 40 ºC	T/S
TEOM-1405	JPP-kalibrointi ky, FMI	Tapered Element Oscillating Microbalance	US-EPA	Heated 50 ºC	T/S
OSIRIS	Hnu-Nordion (Finland) / Turnkey Instruments	Optical (nephelometer)	Osiris	Heated 35 ºC	T/S
DUST TRAK DRX 8533	Oy Teknocalor Ab (Finland)/ TSI Inc (USA)	Optical (light scattering)	TSI	Ambient	S

The companies of Environnement SA (France), HNU-Nordion/Turnkey Instruments (USA) and Oy Teknocalor Ab/ TSI Inc (USA) each provided two CMs for the tests. The Finnish Meteorological Institute (FMI) provided two SHARP, two FH 62 I-R and one TEOM 1405. One TEOM 1405 was provided by JPP kalibrointi Ky. The Estonian Environmental Research Centre provided two BAMs. Maintenance of the Thermo Fisher instruments (FH 62 I-R, SHARP and TEOM) as well as the sampling inlets was provided by Oy Kontram ab and Sintrol Oy provided spare parts for the BAMs.

The size selective inlets used for RM and CMs are shown in Figures 2.12 and 2.13. In case of Grimm, Osiris and DustTrak the sampling inlets were not size selective but the size classification is obtained by light scattering.

Figure 2.12. The sampling inlet for the reference method used in Leckel: Complete (in the left), separated (in the middle) and the impactor plate (in the right).

Figure 2.13. Size selective inlets used for CM: EU-Digitel (FH 62 I-R, SHARP), US-EPA (BAM) and EU-Environnement (MP101).

There are differences on the sampling efficiency of the size selective inlets with cut size of 10 µm, shown in Figure 2.14 (Kaminski and Kuhlbusch, 2010). The blue and pink curve represents the EU inlet with different distance of impactor plate from the jets. The standard allows a distance variation of 8 ± 2 mm. The black curve presents an inlet where the distance is larger than allowed. The other two curves, the US-EPA inlet (red spots) and according to German standard DIN EN 481 (green curve) which is designed for working environment condition agree with each other very well, but are not so steep in cut off size than the others. The cut off size of 50 % efficiency is between 9.73 to 10.28 µm for the inlets according to EU-design, while the US-EPA and DIN EN 481 collect larger particles than the EU-inlets but is also smoother in the smaller size.

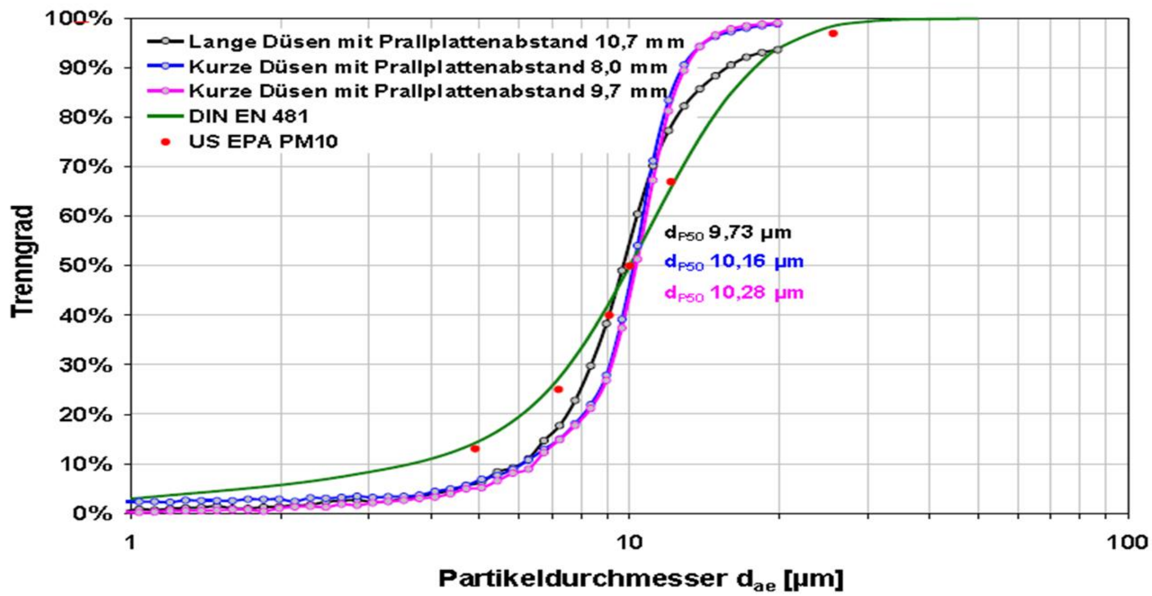

Figure 2.14: The sampling efficiency curve for PM_{10} particles with different design criteria.

2.4. Equivalence procedure

The analysis of the comparison data was conducted according to the GDE. Before the analysis of the equivalence tests, a preliminary assessment needs to be made in order to ensure that the CM:

- fulfils the requirements of data capture and time coverage set for continuous/fixed measurements; and

- has the potential to meet the uncertainty criteria of the data quality objective at the limit or target value concentration for continuous or fixed measurements of the specified pollutant

After the candidate method has passed this preliminary assessment, the test and evaluation programme relevant to the candidate method can be selected. In the case of PM measurements, the tests are performed according to test programme number 3: Methods for particulate matter. Both laboratory and field tests need to be considered. Laboratory tests are needed in case if deviation from the EN-standard takes place either if:

- the automated filter changer maintains a different storage conditions of the sampling filters than prescribed or
- use of different weighing conditions of the filters in the weighing room or weighing chamber

It should also be pointed out that the limiting conditions for claiming of the PM equivalence are associated with site specific conditions, ranges of fractions of the constituent as well as the size or shape of the particles. This means that even though the generalization of equivalence claim is valid for a wide range of conditions and compounds, this is not the case for PM. The performance characteristics of the CM are influenced by environmental conditions, but also e.g. by the fraction of a semi-volatile constituent in the sample, which is site-specific and depends also on geographic location. Equivalence claims for a specific CM may thus not be applicable in general, but the CM may still be useable in specific conditions or at certain locations.

The test programme 3 of the GDE is suitable to evaluate a CM for monitoring the $PM_{2.5}$ and PM_{10} fractions of total suspended particulates in ambient air. The equivalence claims can be focused on the sample inlets and/or the measurement method (e.g., β-ray attenuation, optical method, oscillating balance). Basically the procedure for claiming the equivalence of the CM against a RM is a method involving calibration. The term "correction factor" has been omitted from GDE. Field campaigns were performed with the

CMs that took part in the tests. Field tests were performed in such a way that the candidate and the reference methods were compared side-by-side. Two CMs of the same model, as well as two RMs, were included in the tests. The measurements were designed to assess:

- 'between-sampler/instrument' uncertainty of the candidate method through the use of two samplers or instruments
- 'comparability' of the candidate and reference methods

The GDE requires two identical CMs but allows one RM to be used for tests. However in this case a default value for the uncertainty of the results of the reference method $u^2 = 0.67$ $(\mu g.m^{-3})^2$ may be used, see Eq (2.1).

The evaluation of the collected data included the following steps:

A *Suitability of datasets*

According to GDE, data may only be removed from the dataset when sound technical reasons can be found for doing so. However, when suspicious data are found, as discovered by, e.g., Grubb's test, it is permitted to remove up to 2.5 % of data pairs, as long as the number of valid data pairs per comparison is ≥ 40.

Of the <u>full dataset</u>:

1. ≥ 20 % of the results obtained using the reference method ≥ UAT

where UAT is the Upper Assessment Threshold for the annual limit value. For PM_{10}, the UAT is 28 µg/m^3, while for $PM_{2.5}$ it is 17 µg/m^3.

B *Between-sampler/instrument uncertainty*

The between-sampler/instrument uncertainty is determined for CM by calculation the differences of all 24 hour results for each pair of CM's. The standard uncertainty of the between-sampler/instrument uncertainty is then calculated from the differences as:

$$u_{bs}^2 = \frac{\sum_{i=1}^{n} (y_{i,1} - y_{i,2})^2}{2n} \qquad (2.1)$$

where $y_{i,1}$ and $y_{i,2}$ are the averages of results of CM over 24 h period i and n is the number of 24 hour measurement results.

The u_{bs} is determined for the data set in the following way:

- for the complete dataset
- for splitted dataset:
    - for PM_{10}: concentrations ≥ 30 µg/m³
    - for $PM_{2.5}$: concentrations ≥ 18 µg/m³

A between-sampler/instrument uncertainty $u_{bs} \leq 2.5$ µg/m³ shall be met for both of the data sets for PM_{10} and for $PM_{2.5}$. If this is not achieved, it is an indication of unsuitable performance of either one or both samplers and instruments, and equivalence shall not be declared for the candidate method when this criterion is not satisfied.

For the reference method, RM, the between-sampler/instrument uncertainty, u_{bsRM}, shall fulfill the criterion, $u_{bs,RM} \leq 2.0$ µg/m³.

C *Comparison with the reference method*

Evaluation of the uncertainty due to the 'lack of comparability' between candidate and reference methods is established as the average of both of the CM's and that of each of the candidate instruments individually (GDE (09)) using a regression technique that leads to symmetrical treatment of both variables. The relationship between the measurement results of both methods can be described by a linear relation of the form:

$$y_i = a + bx_i \tag{2.2}$$

where *a* is the intercept and *b* is the slope of the linear line. The procedure of comparisons is applied to the average of RM and to each of the candidate instruments individually for the full dataset obtained and to a number of subsets:

- *full data set*
- *datasets representing PM concentrations*
  - $\geq 30\ \mu g/m^3$ *for* PM_{10}*, or*
  - $\geq 18\ \mu g/m^3$ *for* $PM_{2.5}$*,*

  provided that the subset contains 40 or more valid data pairs
- *datasets for each individual site*

Preconditions for acceptance of the full dataset are:

- the slope *b* is insignificantly different from 1: $|b-1| \leq 2 \cdot u(b)$ and (2.3a)
- the intercept *a* is insignificantly different from 0: $|a| \leq 2 \cdot u(a)$ (2.3b)

where the *u(b)* and *u(a)* are the standard uncertainties of the slope and intercept. If these preconditions are not met, the CM may be calibrated using the values obtained for the slope and/or intercept. The calibration shall only be applied to the full dataset. The algorithms for the calculation of the standard measurement uncertainties of *u(a)* and *u(b)* are related to the results of the individual CM against the results of the RM (see Annex b in GDE).

From above one can see that there is no general requirement regarding how much *a* can deviate from zero and *b* deviate from 1. Instead, the smaller *u(a)* and *u(b)* are, the smaller deviation is allowed in the significance test for the intercept (= 0 ± *a*) and for the slope (= 1 ± *b*), respectively. Therefore no rejection of the CM has been made based on the values of *a* and *b*.

The procedure is applied for each specific situation for which a separate claim is made, e.g. for specific site type (GDE). The tests of equivalence for each of the full data and for the subset data were performed with the Excel macro prepared for the data analysis by RIVM (R. Beijk, 2011). The macro includes calculation of the combined standard measurement uncertainty, u_{CR}. The combined standard uncertainty, u_{CR}, includes the uncertainty of the reference sampler, which is calculated from the between sampler value, see Eq (2.1). If only one RM is used, $u_{bs,RM}^2$ = 0.67 (µg/m^3)^2 shall be used. However, $u_{bs,RM}^2$ = 1.0 (µg/m^3)^2 is used as default value in any case. The equation of the u_{CR}.can be expressed in the form:

$$u_{CR}(y_i) = \sqrt{\frac{RSS}{(n-2)} - u^2(x_i) + [a + (b-1)x_i]^2} \qquad (2.4)$$

Where

RSS = the sum of (relative) residuals resulting from the orthogonal regression

$u(x_i)$ = uncertainty of the results of the reference method

where RSS can be expressed as:

$$RSS = \sum_{i=1}^{n} (y_i - a - bx_i)^2 \qquad (2.5)$$

The relative combined standard uncertainty, $w_{c,CM}$, is then calculated as:

$$w_{c,CM}^2 = \frac{u_{CR}^2}{y_i^2} \qquad (2.6)$$

where y_i is the limit value of $PM_{2.5}$ or PM_{10} used for the calculation. The limit values used here are 30 µg/m^3 for $PM_{2.5}$ and 50 µg/m^3 for PM_{10} (GDE). The calculated relative8expanded measurement uncertainty, W_{CM}, can be expressed as $W_{CM}=k \cdot w_{c,CM}$, where the coverage factor k=2. When comparing W_{CM} with the data quality objective (DQO) of the AQD (see in Table 2.1), the following two cases apply:

1. $W_{CM} \leq W_{DQO}$: the CM is accepted as an equivalence method to the RM (2.7a)
2. $W_{CM} > W_{DQO}$: the CM is not accepted as an equivalence method to the RM (2.7b)

In case 2, the results of the CM can be corrected using the results from the regression equation, Eq. (2.2), obtained for the full dataset. The term calibration is used here for correcting the data. The form of calibration equations depends on the conditions in Eq (2.3a and b):

1. *b* and *a* significantly difference from 1 and 0, respectively: $y_{i,cal} = \frac{y_i - a}{b}$ (2.8a)
2. *b* significantly different from 1: $y_{i,cal} = y_i / b$ (2.8b)
3. *a* significantly different from 0: $y_{i,cal} = y_i - a$ (2.8c)

After applying the calibrated equation, the recalculated relative expanded measurement uncertainty, $W_{CM,cal}$ of the CM needs to satisfy requirement 1 in Eq (2.7a) for the full dataset as well as for each of the subsets. If this is not met, the CM is not a method equivalent to the reference method.

The calibration equations obtained for the candidate methods should also be used for the station PM-analyzer if applicable, to demonstrate the equivalency between the station method with the reference method.

The sampling treatment of the CMs is somewhat different with each other (see in Table 2.2). In some cases, the sample tube is heated to avoid condensation and in some case the sampling tube consist of shield flow to maintain the sample at ambient temperature to avoid condensation. In some CM the sample tube include the shield flow but is also equipped with a drier to remove excessive water content in the sample flow, and in some CM there is no additional treatment for the sampling. The sampling treatment has a consequence also for the evaporation of semi-volatile components from the sample. Especially this is important in case of heated sample tubes since evaporation of the semi-volatile compounds occurred already at room temperature. The fraction of semi-volatile compounds in the air has been studied for inorganic ions in the size fraction of $PM_{2.5}$ in Helsinki in 2006–2007 (Timonen et al. 2014) and at a background station in the southern part of Finland during the period of 2003 to 2009 (Ruoho-Airola, 2012). The major semi-volatile compounds considered here are the NH_4^+, NO_3^-, and SO_4^{2-} ions. In both studies a clear diurnal and seasonal behavior was observed. Sulphate was the most abundant ion with an average concentration of 1.7 µg/m^3. The concentration of nitrate and ammonia were considerably lower i.e. 0.7 and 0.8 µg/m^3, respectively. The sum of the average mass concentration of the most easily evaporated compounds i.e. ammonia and nitrate is 1.5 µg/m^3. If half of the amount evaporates at 20 °C this means 10 % at the average concentration of $PM_{2.5}$ which was 7.3 µg/m^3 over the whole comparison period. On the other hand, the proportion of semi-volatile compounds to whole mass of $PM_{2.5}$ was estimated to be on 18 % based on the measurements by TEOM using the FDMS (Timonen et al. 2014).

3. Experimental set up

3.1 Laboratory tests

The GDE defines the circumstances in which the laboratory tests are needed. The laboratory tests are not required for CM's but only for RM if deviations from the prescribed conditions according to EN-standard (EN 12341, 2014) occurred.

During these comparisons the reference sampler, SEQ47/50-CD, used for comparison studies was a sequential sampler which can be loaded with 15 sampling filters. The instrument is equipped with a Peltier cooler to maintain the sampled filters at temperature

≤ 23 °C as is required by the EN 12341:2014. In winter conditions the filter cartridge will be automatically heated.

The other requirement where the laboratory tests are needed is when the conditioning conditions of the sampling filters deviate from those prescribed by the EN-standard. The weighing system of the filters was made in house and validated according to the standard. The weighing system is also accredited according to ISO EN 17025:2005. The scope of accreditation covers the mass range of the sampled filters from 0.055 to 55 mg, which corresponds with a mass concentration of 1 to 200 $\mu g/m^3$ (http://www.finas.fi/Scopes/K043_M11_2015.pdf). The environmental conditions of the weighing system are controlled and recorded and actions are taken in case of deviations from prescribed conditions.

Based on the performance characteristics of the reference sampler and that the conditions inside the weighing facility of the filters followed the EN 12341 requirements, no additional laboratory tests were conducted (GDE, 2010).

3.2 Field campaigns and the measurement site

The equivalence comparisons took place during March 2014 and July 2015. The site for comparison tests was selected in the city of Kuopio, some 400 km northeast from the city of Helsinki. The location represents inland conditions and is not influenced by marine climate. The city is surrounded by lakes and forest and agriculture area. There are some 110 000 inhabitants in Kuopio.

Figure 3.1: The measurement sites in the city of Kuopio. The left map shows the local air quality networks in Finland and on the right the location of the two measurement sites in Kuopio are shown.

The equivalence tests for the candidate measurement methods against the reference method for $PM_{2.5}$ and PM_{10} were conducted at two sites in the city of Kuopio. The sites were selected based on a preliminary assessment study of the air quality in the city of Kuopio by dispersion modelling, and on the annual reports of air quality in the city of Kuopio. The exceedances of daily limit values of mass concentration of PM_{10} occur regularly between 20 to 30 times per year. Mostly these exceedances occur in conditions, where due to the winter sanding to enable safe road traffic against the ice both for pedestrians on the sidewalks and for cars on the roads, the sand particles are resuspended into the air by the winds. This causes the elevated mass concentration particularly in the PM_{10} size class. Not only the winter sanding but also the use of studded tires in cars causes particles that are resuspended into the air. At the Savilahdentie there is no existing air quality station but the site was selected for comparison study based on the dispersion model estimations which showed high concentrations of PM due to traffic. The test started at the air quality station in Tasavallankatu with two PM_{10} comparison campaigns in series followed by two campaigns for $PM_{2.5}$. The change of site to Savilahdentie took place right after finishing the campaigns in Tasavallankatu. Here the strategy for comparison was changed from that in Tasavallankatu. One reference sampler was installed with PM_{10}-inlet and the other with

$PM_{2.5}$-inlet through the rest of the campaigns. The parallel comparisons with only one RM are allowed by GDE but additional uncertainty component is required to be included in the uncertainty budget. The basic reason for the change of strategy was to provide the participation of two different models of CMs in the tests. Both of the CMs were able to measure both size classes at the same time. The change of strategy was agreed in very early stage of the comparison due to the lack of space at Tasavallankatu. However, at the beginning of the measurement campaigns at Savilahdenkatu only one of the two different CMs was submitted in the test, namely DustTrak model DRX 8535 by TSI Inc., which is an optical method. The other method was withdrawn from the comparison.

At Tasavallankatu the first PM_{10} comparison tests started in 2014 with a spring campaign on March 20 to May 10 consisting of 51 daily samples for RM. The second PM_{10} comparison, summer campaign, continued from May 11 to July 14, consisting of 52 daily samples for RM. The first $PM_{2.5}$ campaign started with summer tests from July 17 to October 1 including 60 daily samples for RM. The second campaign for $PM_{2.5}$ continued on October 2 and ended on December 1, including 60 daily samples for RM.

At Savilahdentie the comparisons continued with two campaigns for PM_{10} comparisons followed by two campaigns for $PM_{2.5}$ comparisons for those CMs which have size selective inlets i.e. with FH 62 I-R, MP101_CPM, SHARP, TEOM 1405 and BAM. At the beginning of the campaigns at Savilahdentie there was a short period when both of the RMs were installed with PM_{10} inlets to check the consistency of the samplers. The third campaign of PM_{10} comparisons for those having size selective inlets started on December 5, 2014 to February 5, 2015 including 50 daily samples for RM. The fourth PM_{10} comparisons started on February 6 to April 8 including 50 daily samples for RM. The third campaign of $PM_{2.5}$ comparisons started on April 5 to May 21 including 41 daily samples for RM. The fourth campaign of $PM_{2.5}$ comparisons started on May 22 to July 7 including 42 daily samples for RM. At Savilahdentie parallel measurements by reference method were conducted for $PM_{2.5}$ and PM_{10} measurements allowing Grimm, DustTrak and Osiris to conduct simultaneous comparison for $PM_{2.5}$ and PM_{10}. This meant that there were four comparisons for $PM_{2.5}$ and PM_{10} at Savilahdentie for the CMs following the optical methods but two campaigns for $PM_{2.5}$ and PM_{10} using the size selective inlets. In Figure 3.2 the different field campaigns are shown.

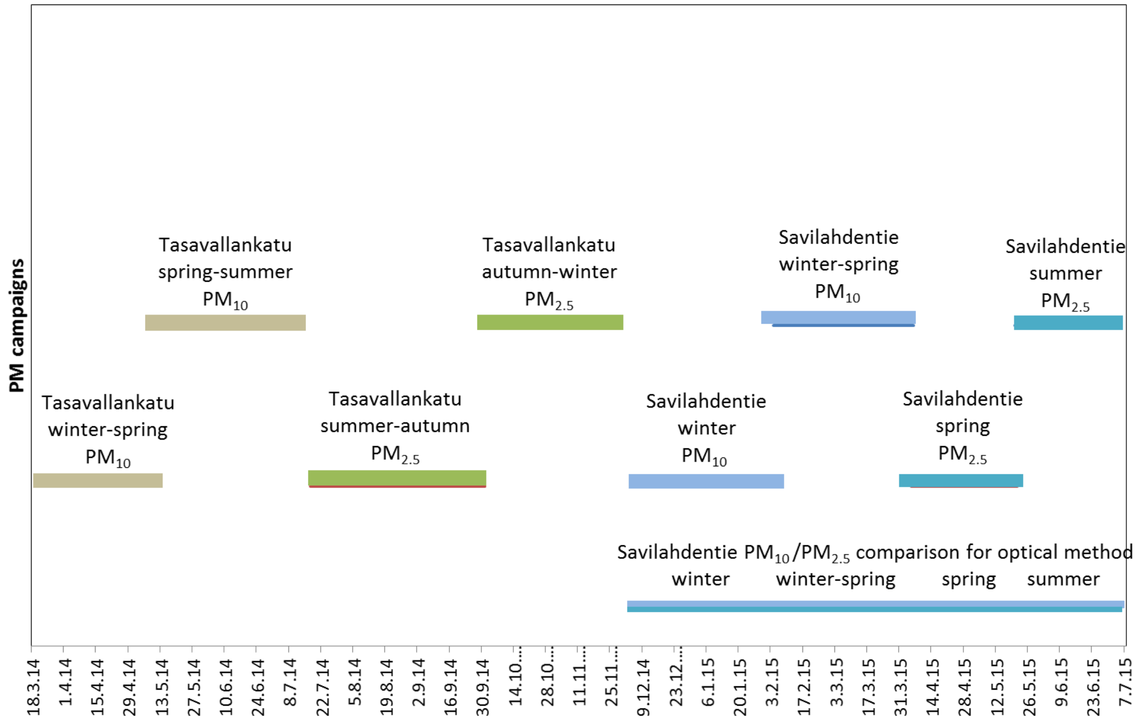

Figure 3.2: The dates of the equivalence test campaigns for $PM_{2.5}$ and PM_{10} at Tasavallankatu and at Savilahdentie. At Savilahdentie the parallel measurements of $PM_{2.5}$ and PM_{10} by RM allowed simultaneous comparison of $PM_{2.5}$ and PM_{10} by CMs based on optical methods.

The measurement station at Tasavallankatu, see Figure 3.3, is located beside main road (6 m from the kerbside and 60 m from the closest crossing) from the motorway to the center of city of Kuopio. In the neighborhood, there is also a residential area with private houses. Most of the houses have their own heating system by wood. The main power plant, which takes care of heat production in the area, is located near the site. The energy source is peat pellet, which is transported with trucks. The traffic density at Tasavallankatu is some 22 000 vehicles/day. At the air quality station, mass concentration of $PM_{2.5}$ and PM_{10} and the concentration of nitrogen oxides are measured. The station was classified as a traffic station according to the AQD. The meteorological parameters, wind speed and direction, air temperature, pressure and relative humidity are also measured.

Figure 3.3. The air quality measurement site at Tasavallankatu in the city of Kuopio. The measurement van and the cabin are shown in front. The green cabin in behind is for the air quality measurement station.

The Savilahdentie site is a traffic station, 10 m from the kerbside and more than 200 m from the closest crossing. The station lies between the freeway from south to north splitting the city of Kuopio and the Savilahdentie which is the motorway connecting the industrial area, shopping centers, university campus area and the techno polis area to the city. The traffic density is about 21 000 vehicles/day, consisting mostly of working traffic but also some drive through traffic. The measurement cabins were installed beside a small relay pumping station.

Figure 3.4. Savilahdentie site.

3.3 Filter weighing procedure

The EN 12341 standard describes the environmental conditions for filter conditioning during the filter weighing process. The environmental conditions prescribed by the standard are (20 ± 1) ºC for the temperature and (45 to 50) % for the relative humidity. The weighing facility of the filters was made in house, consisting of the weighing chamber and the conditioning and control system. The schema of the operation is shown in Figure 3.5. The environmental condition inside the weighing facility is gained by injecting dry air obtained from the laboratory compressed air system through the water bath and the humidifying system into the weighing chamber. The dry air flow rate is controlled by mass flow controllers and injected through the Perma-pure humidifiers at temperatures controlled by water baths. The first water bath (VH1) and the humidifier (PPK1) are to reach the conditions in temperature and water content close to the requirements by the standard and the second (VH2 and PPK2) are used more for adjustments. The conditions are recorded by the dew point measurement probe (dew point and temperature transmitter, DMP 248) by Vaisala. The data was stored in the laboratory computer MICRO COMPUTER with software made in house. The filters were weighed by ultra-micro balance (XP2U) by Mettler Toledo with repeatability of 0.25 µg as standard deviation and a resolution of 0.1 µg. The calibration of the laboratory balance carried out once a year by an accredited calibration laboratory through which the traceability of the weighing results is linked to the national standard. In addition, the tare of the balance was checked on a daily basis by an automated function of the balance. The balance is connected to the readout unit and to a laptop where the BalanceLink software by Mettler Toledo was installed for collecting weighing results of the filters. The filter trays inside the chamber were capable of carrying more than 30 filters inside the chamber. The filter weighing facility is shown in Figure 3.6.

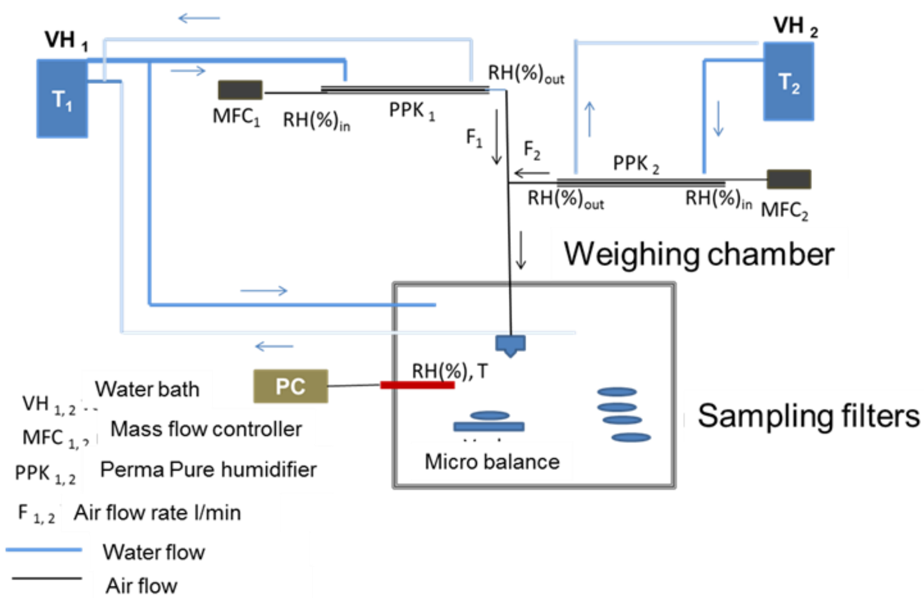

Figure 3.5. Schematic layout of the control system for weighing the filters for the reference method.

Figure 3.6: The weighing box for the filters and the control units for conditioning of temperature and humidity (on the left) with the balance (on the top middle) and the filter tray (on the right).

The conditioning and the conditions during the weighing of the filters were kept within the requirements by the EN-standard EN 12341:2014. Once exceedance of the allowed limits occur the weighing was postpone until the conditions were acceptable.

3.4 Data acquisition system at the measurement site

The data acquisition system used for the PM equivalence comparisons was a commercial EnviDas2000 for Windows (EnviDas, 2003) installed in a microcomputer. The data was collected as an average of 15 s values once a minute from every CM. The data protocols for each of the CMs were installed in the software with the help of the manufacturers. Two identical data acquisition systems were used so as to have all the CMs continuously connected. The station microcomputers were connected through a modem line with the server computer where the data management software, Enview 2000 (Enview, 2004), was installed. Enview software stored the data in the database of the FMI for further analysis.

3.5 Operation of the instruments

3.5.1. Reference sampler

Two identical sequential samplers, SEQ47/50 from Leckel (see Figure 2.2) were used as a reference sampler. Up to 15 filters were loaded in the filter cartridge. One filter was used as a field blank for each of the samplers and 14 filters were used for defining the mass concentration of PM during the 24 h sampling time. The storage condition for the filters in the reference sampler follows the conditions set up by the EN 12341 standard. The samplers were installed on the roof of the measurement cabin, shown in Figures 3.3 and 3.4. The sampling with both of the samplers started at 10 am on each day. The time interval of ± 1 h was reserved for the loading and unloading of the sampling filters for every two week period.

3.5.2 CM operating conditions

The candidate methods were installed inside the cabin or the measurement van. Exceptions to this were the Osiris and DustTrak, which were installed on the roof. The location of these two CMs was approved by both manufacturers. The sampling inlets of the CMs were installed at varying heights from the roof level, from 60 cm up to 180 cm. The free circle around the sampling inlets was 120 cm in diameter or larger. The conditions inside the cabin and the measurement van were controlled by an air-conditioning system maintaining the inside temperature between 20 to 25 °C through the whole comparison study. Power failures occurred especially in the beginning of the measurements when the site was changed. The UPS system protected the microcomputers for data collection but not the CMs.

3.5.3 QA/QC procedures

The QA/QC procedures for the CM and for the RM stated by the GDE are listed in Table 3.1. The sampling flow rates for the reference samplers and the CMs equipped with the size selective inlets are presented in Annex A1, Table A1a. The flow rates were measured with a mass flow meter by TSI Inc, model 4043. The mass flow meter was calibrated at the calibration laboratory of the Finnish Meteorological Institute, which maintains the traceability of the primary calibration facility to the national metrology institute by regular calibration against the primary flow calibration method. The uncertainty of the flow calibration facility at the sampling flow rate of the size selective inlets is 0.7 % (https://www.finas.fi/Documents/K043_M12_2016.pdf). The uncertainty of the mass flow meter of TSI model 4043 was estimated based on the calibration certificate as 1.5 % as expanded uncertainty. The flow measurement of SHARP (in Table A1a, SHARP A) turned out to be problematic due to the connection of the sampling tube which did not fit well with the flow meter. The connection was improved at the same time as the change of inlets. The temperature and the pressure for each of the flow measurements were also recorded and are presented in Tables A1b and A1c. The sampling flow rate of the CMs operated by optical methods were checked by the Finnish representative (Hnu Nordion Oy, for Osiris) or by the manufacturer (Grimm 180 and DustTrak). The sample flow rates of the CMs were also recorded by the data acquisition system where applicable.

The cleaning of the size selective inlets was conducted according to the recommendation by the manufacturers of the CMs. In case of RMs the cleaning of the inlets was conducted according to the EN-standard (EN-12341). The time schedule for cleaning of the filters is presented in Annex A1.d. The impactor plates were wiped by silicon vacuum grease after the cleaning of inlets in order to prevent the larger particles than the cut off size to bounce off the plate. The grease of the impactor plate needs to perform according to the EN-standard or according to the instructions by the manufacturer. There are some differences in the instructions by the manufacturers of the inlets e.g. in case of the US-EPA inlet the impactor plate is not greased, but instead the O-ring and the O-ring seat need to be greased according to the manufacturer’s instruction (inlet manual BX 820-9800).

The Finnish representatives conducted the maintenance of the CMs except in case of BAM, where the maintenance was conducted by a technician from the EERC.

Table 3.1. The QA/QC procedures conducted at the measurement sites for the CMs and RMs.

Calibration, checks and maintenance	**Frequency**	**GDE/FMI**	**Action criteria**
Checks of status values of operational parameters	Daily	GDE	If error messages occurred, contacts to local network operator or representative.
Checks of sensors for temperatures, pressure and/or humidity	Every 3 months or according to manufacturer	GDE	If deviations larger than acceptable, contacts to local representative: T: ± 2 °C P: ± 1 kPa RH: ± 5 % RH
Check of sampling velocity	Every 2 months	FMI	Adjustment if deviation > 4 %
Cleaning and greasing size selective inlets	Every 1 months (RM) Every 2 months (CMs)	FMI	
Zero check of the CM reading	Every year	FMI	2 µg/m^3
Calibration of the CM	According to manufacturer	FMI/ Representatives	
Maintenance of the CM	According to manufacturer	FMI/ Representatives	

3.5.4 Field audit

The field audit was conducted on the QA/QC procedures and the operation of the instruments. The audit was performed by external auditors at the measurement site as required by the GDE due to lack of accreditation of the Finnish Meteorological Institute. During the audit, the procedures for conducting the QA/QC procedures according to Table

3.1 were checked through demonstration of the activities at the site and examining the logbook. The auditors were experienced in air quality measurements, content of the relevant EN-standard, quality systems and are responsible for the air quality network in the city of Kuopio.

4. Data analysis

4.1 Description of the database

The data from the CMs was collected as minute readings by commercial EnviDas data acquisition system. The data was stored in the memory of the station microcomputer and transmitted over a GSM modem connection once a day to the data server at FMI. A few exceptions from the minute values occurred. In case of DustTrak, the data was stored in the memory of the device where it was copied to the memory stick every two weeks and stored on the server of FMI for data analysis. The frequency of the data collection from DustTrak was every 4 seconds. In case of one of the Grimm instruments, the data needed to be collected through the HyperTerminal software into the station micro computer. In case of the BAMs, the sampling time was set to three hours which means that the data values were constant during this period reaching another value after each 3 hour period. The change of period was synchronized with the time of change of the filters in the RM. In the data server of FMI, the Enview software stored the data in the database. In case of the RM, the results of the sampling, i.e. the sampling time, the sampling flow rate, and the sampling volume were collected every time when filters were changed from the memory stick of the RM and stored on the on the server computer of FMI.

The data base of the equivalence tests for $PM_{2.5}$ and PM_{10} includes the minute values, hourly values, and 24-hourly values for the CMs. The 24-hourly values were calculated during the sampling time of the RM. In addition to the mass concentration of the CMs, also data of the diagnostic information of CMs was collected. Such diagnostic information includes the sampling flow rate, the temperature, the relative humidity, and the signals from optical-, combined- or beta-methods and the cumulative mass concentration were collected when applicable.

4.2 Data processing

During the process of calculating the hourly and 24 h averages, the data was inspected at every step of the calculation, starting from the minute values to see the response of each CM. The averages for the different time intervals were performed, provided that 75 % of the data was available over each calculation period. The notes and observations made in the logbooks of the RMs or CMs at both of the measurement cabins were studied. If technical reasons for malfunctioning of any of the RMs or CMs were observed, the data was flagged. In case of the RMs, no technical problems in the operation of the devices occurred. In case of the operation of CMs, several of the reasons e.g. power and pump failures, malfunctioning of measurement probe pointed out by diagnostic information, moisturizing of resulted in incorrect behavior of the CMs. These malfunctioning were checked, and the calculation of the average values was rejected if requirements for averaging the results were not met. The 24 h means for each of the CM were calculated for the same period as RMs.

The following data treatments were performed for PM_{10} and $PM_{2.5}$ (see Ch. 2.4):

- Data capture, (AQD) Pass/Fail
- Test of suitability of the data, GDE Pass/Fail
- Test of between-sampler for each pair of CMs, GDE Pass/Fail
- Test of between-sampler for RMs, GDE Pass/Fail
- Test of comparability, GDE
    - uncorrected data
        - all data (averages of RMs and CMs over whole test campaigns) Pass: OK

Fail: Calibration

- subsets Pass/Fail
- each of the CMs individually Pass/Fail

- calibrated data (if 'all data' failed)
  - all data Pass/Fail
  - subsets Pass/Fail
  - each of the CMs individually Pass/Fail

The tests of comparability were made with reference to the concentration value of 30 µg/m^3 for $PM_{2.5}$ and that of 50 µg/m^3 (the daily limit value) for PM_{10}, according to GDE. If the test failed to meet the DQO criteria for fixed measurements (see Eq. 2.7b), a check was made for the CM as to whether the test value, $W_{,CM}$, fulfilled the DQO for indicative measurements (see Table 2.1). It also occurred that some of the points did not seem to fit with the rest of the data, and therefore Grubb's test or the judgment of an expert was used to remove some of the data points. As stated in GDE, no more than 2.5 % of the data could be removed based on this method.

5. Results

5.1 Meteorological conditions during the equivalence comparisons

The spring 2014 was rather mild compared with the climatological reference period 1981-2010 (Pirinen et al. 2012). The daily mean temperatures (T) and relative humidity (RH %) during the comparison periods in Tasavallankatu and in Savilahdentie are presented in Figures 5.1a and b together with the average of the data from the climatological reference period (1981 – 2010) from Kuopio.

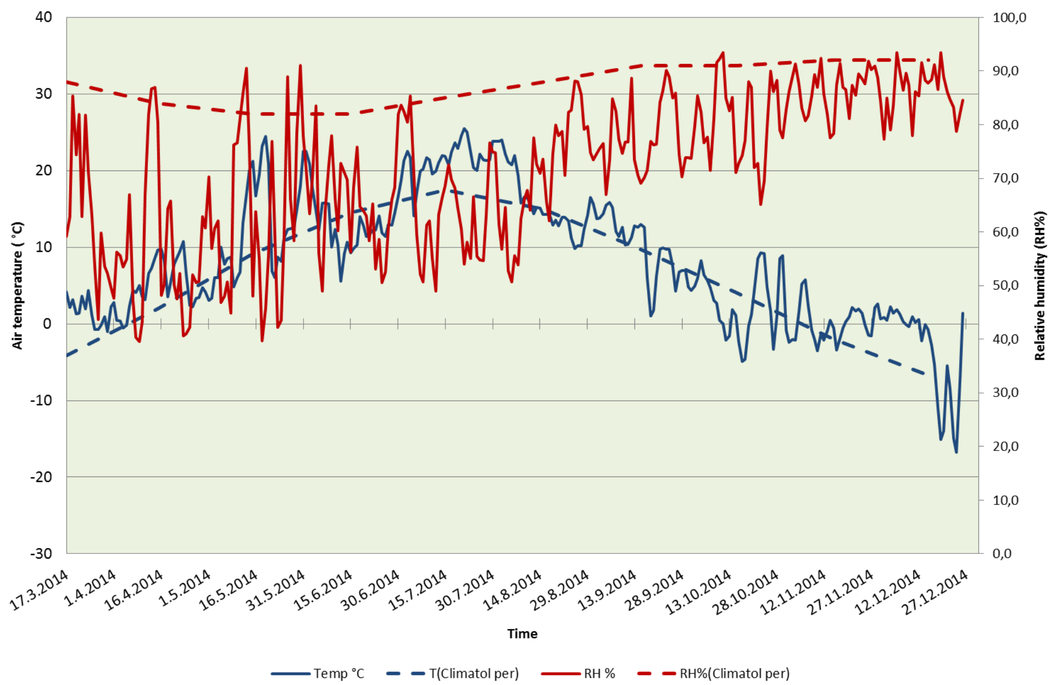

Figure 5.1a: The 24 h mean values of temperature (scale on the left) and relative humidity (scale on the right) during the equivalence campaigns for PM_{10} and $PM_{2.5}$ measurements at Tasavallankatu. The dash lines represents the average of air temperature and relative humidity over the climatological reference period (1981 – 2010) from Kuopio.

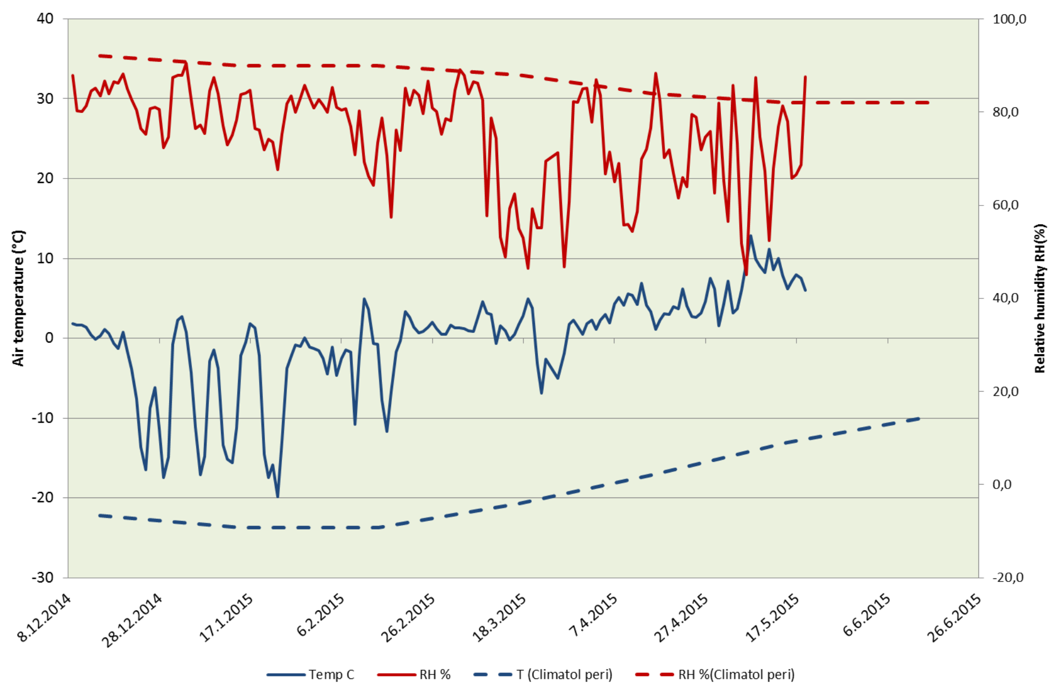

Figure 5.1b. The 24 h mean values of temperature (scale on the left) and relative humidity (scale on the right) during the equivalence campaigns for PM_{10} and $PM_{2.5}$ measurements at Savilahdentie. The dash lines represents the average of air temperature and relative humidity over the climatological reference period (1981 – 2010) from Kuopio.

The roses for wind speed, wind direction, PM_{10}- and $PM_{2.5}$ concentrations are presented from Tasavallankatu in Figure 5.2.a and from Savilahdentie in Figure 5.2.b.

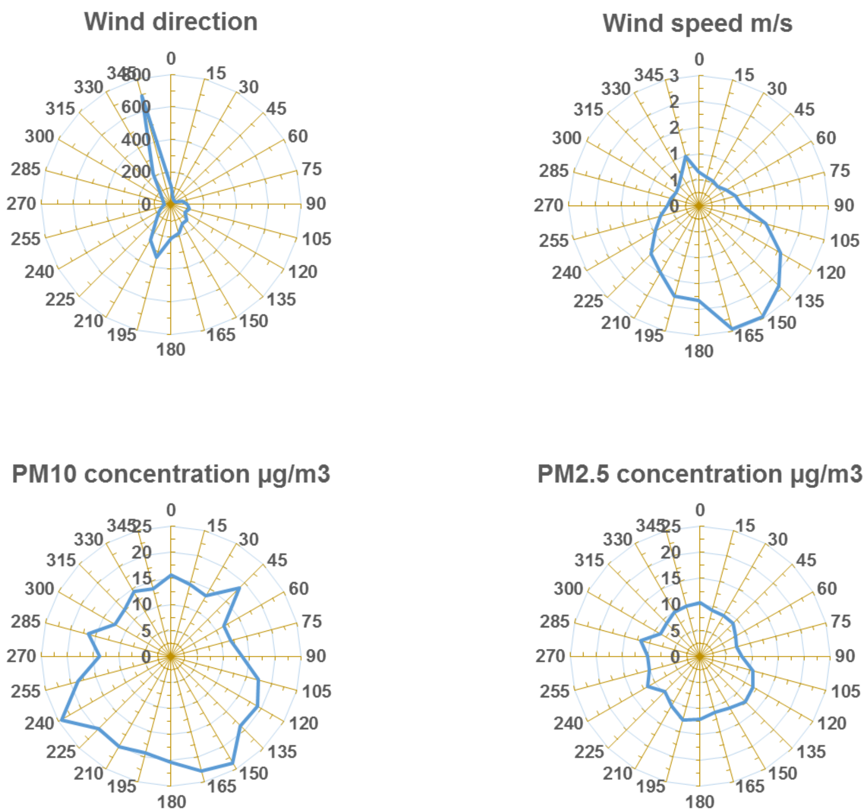

Figure 5.2.a. Wind direction, wind speed, PM_{10} concentration and $PM_{2.5}$ concentration as a function of wind direction during the equivalence campaigns for PM_{10} and $PM_{2.5}$ measurements at Tasavallankatu.

In Tasavallankatu site the wind sector is very narrow indicating that near the ground the wind is along the road, perpendicular to Tasavallankatu (see Figure 3.1) where the strongest winds are blowing from the Tasavallankatu. The PM_{10} concentrations are at the highest at winds from the Tasavallankatu, while the $PM_{2.5}$ concentrations are more evenly distributed to all wind sectors. In Savilahdentie the dominating wind sector is from the lake across the Savilahdentie and from the freeway (see in Figure 3.1). The wind speed is rather evenly distributed to all wind sectors. With the PM_{10} concentrations, a clear peak comes from the

Savilahdentie and from the freeway. In wind sector 30° the particles are emitted from both of the roads. The $PM_{2.5}$ concentration pattern is very similar to that of the PM_{10} concentration but smoother and with much lower concentration.

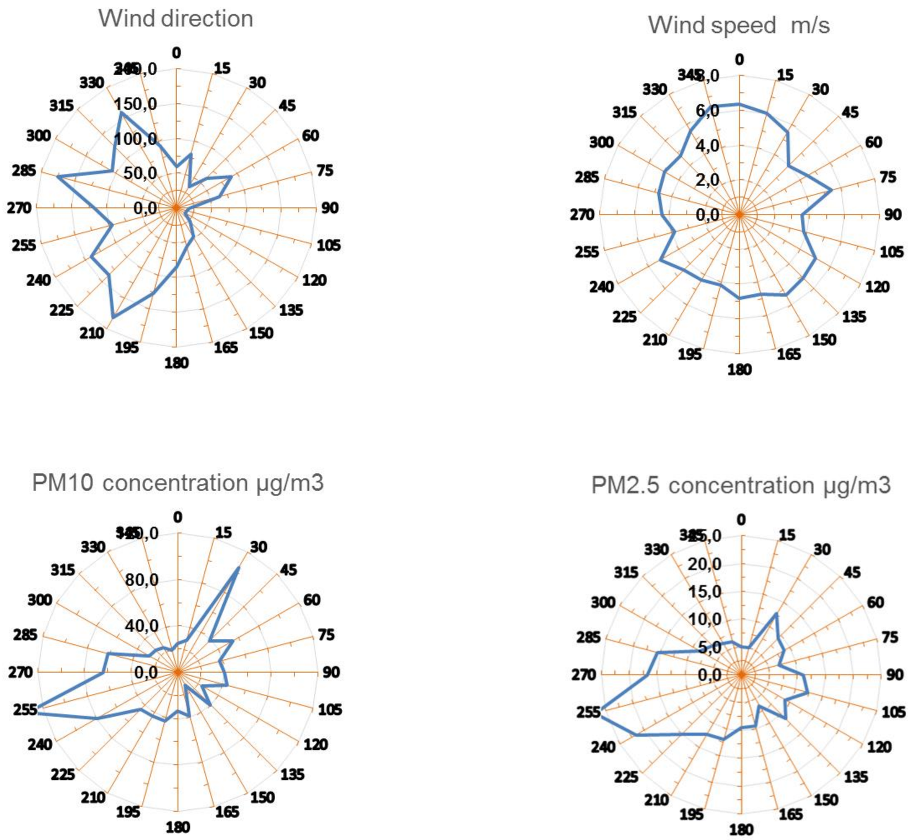

Figure 5.2.b. Wind direction, wind speed, PM_{10} concentration and $PM_{2.5}$ concentration as a function of wind direction during the equivalence campaigns for PM_{10} and $PM_{2.5}$ measurements at Savilahdentie.

5.2 Results of the PM_{10} comparison

The equivalence tests of the candidate measurement methods against the reference method started with the field campaigns for the PM_{10} size class. The timing and the duration of the different campaigns of both size classes are shown in Figure 3.2. The PM_{10} comparison started with a spring campaign March 20, 2014. The timing was important for the PM_{10} size class since resuspension of particles from the ground is the major source to mass concentration in this size class. In March, the weather conditions can typically include high-pressure situations where the temperature can be low during the night, causing an inversion. During the day, the temperature increases as the sunrises helping the mixing of the boundary layer. Dry air does not bound particles but rather accumulate them in the boundary layer causing the elevated PM concentration. The content of the sand particles are mostly silicon, which may give a different response with the CM analyzers compared to a normal case where the particles are generated and formed from other processes and sources. Later in spring the city authorities are cleaning

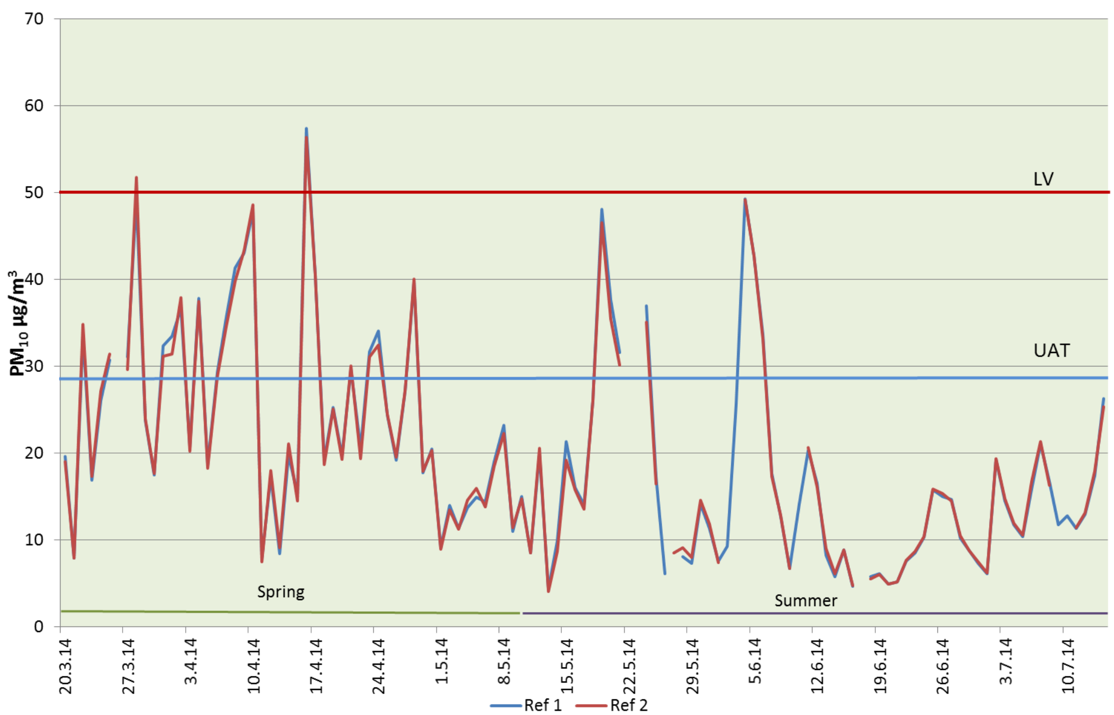

Figure 5.3a: The time series of the two RMs for the PM_{10} comparisons at Tasavallankatu. LV is the limit value for 24 h mass concentration for PM_{10} and UAT is the upper assessment value for PM_{10}.

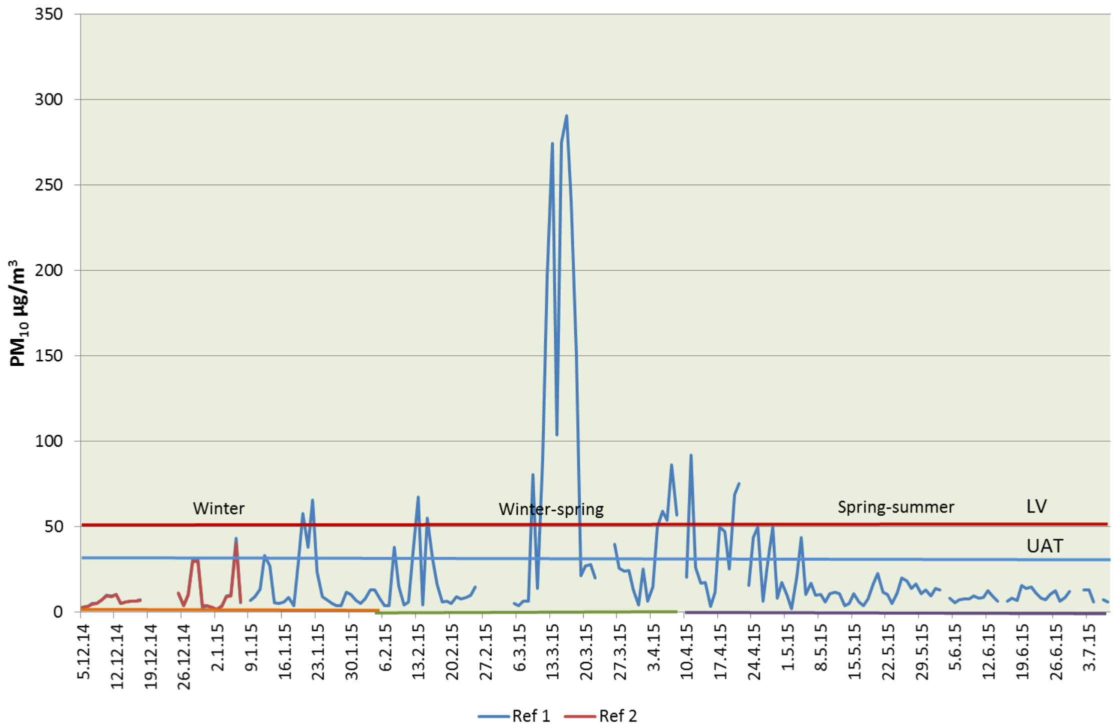

Figure 5.3b. The time series of the two RMs for the PM10 comparisons at Savilahdentie. LV is the limit value for 24 h mass concentration for PM10 and UAT is the upper assessment threshold value for PM10.

the roads and pedestrian walkways from winter sand, which can also cause short peaks in the mass concentrations of particularly PM_{10}.

In Figure 5.3, the time series of daily concentrations of the RMs for PM_{10} for two campaigns at Tasavallankatu (5.3.a) and at Savilahdentie (5.3.b) are shown. The annual Upper Assessment Threshold value of 28 $\mu g/m^3$, and the daily limit value for PM_{10} of 50 $\mu g/m^3$ are shown. Especially in Figure 5.3.b the episode from the inversion situation is clearly seen. The scatter plot of RM2 against RM1 is shown in Figure 5.4. The standard uncertainty for the between sampler test for the reference method, according to eq. (2.1), is 0.6 $\mu g/m^3$ for all data and for the data of > 30 $\mu g/m^3$.

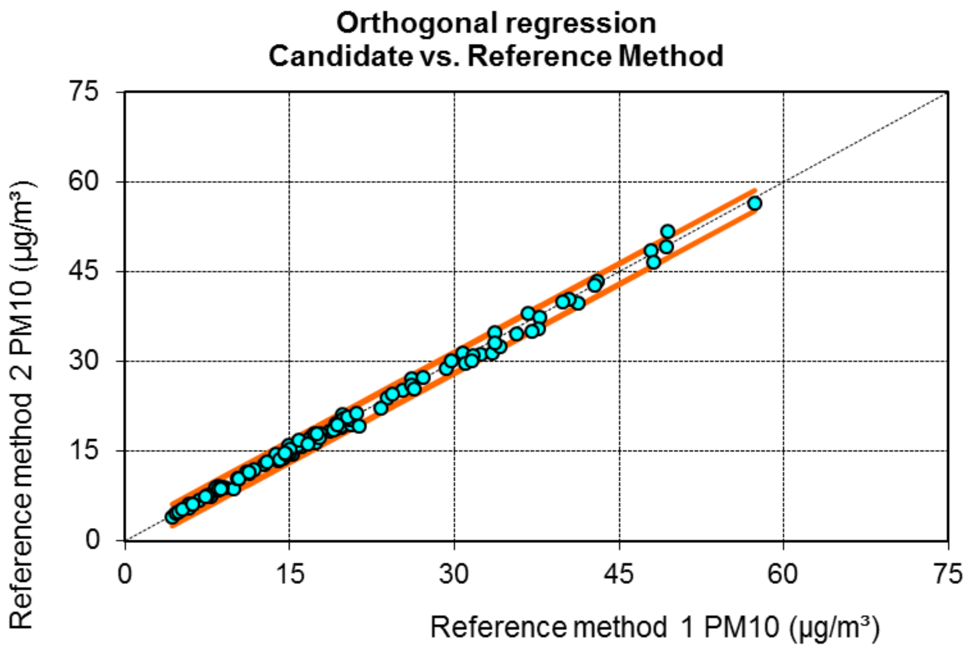

Figure 5.4. The scatter plot of RM2 against RM1 for PM_{10} at Tasavallankatu.

5.1.3. Results of the candidate methods for PM_{10}

In the following tables each of the CMs have been analyzed against the reference method as described in chapter 4.2. The analysis includes the data capture, suitability of data, between CM tests and comparability test. The comparability test includes the tests of significance for slope and intercept indicating if the calibration function for CM is required. The comparability tests are performed for each of the campaigns as well as to two different category of thee data i.e. larger than 30 µg/m^3 and less than 100 µg/m^3. The calibration equation according to Eq. (2.8a) is expressed in any case i.e. irrespectively if the slope *b* and/or *a* are significantly different from 1 and 0, respectively. The results that exceeds the acceptable limit, see in chapter 2.4, are printed in red color.

Table 5.1: The test results for the BAM impactor in all the tests for demonstration of equivalence for PM_{10} measurements.

Test PM_{10}	Criteria	BAM A + B	BAM A	BAM B	Pass/Fail
Data capture	≥ 90 % of RM	**98,6 %**	**98,1 %**	**98,6 %**	**Pass**
Suitability of data	20 % > 28 µg/m^3	**Pass**	**Pass**	**Pass**	**Pass**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**1,32**			**Pass**
> 30 µg/m^3	u_{bs} < 2.5 µg/m^3	**2,03**			**Pass**
Test of comparability					
All data					
Number of data		**211**	**210**	**211**	
Slope	Significant	**1,06**	**1,07**	**1,06**	
Intercept	Significant	**-0,5**	**0,1**	**-1,0**	
Calibrated data					
All data					
Number of data		**211**	**210**	**211**	
Calibration		**0,942y + 0,437**	**0,935y -0,065**	**0,948y + 0,922**	
Expanded relative uncertainty	25 %	**12,6 %**	**13,2 %**	**11,9 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**53**	**53**	**53**	
Calibration		**0,800y + 1,976**	**0,795y + 1,506**	**0,801y + 2,523**	
Expanded relative uncertainty	25 %	**11,5 %**	**13,1 %**	**10,6 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**54**	**54**	**54**	
Calibration		**0,935y + 0,92**	**0,923y + 0,436**	**0,946y + 1,439**	
Expanded relative uncertainty	25 %	**5,7 %**	**7,1 %**	**4,7 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**55**	**54**	**55**	
Calibration		**1,020y + 1,412**	**1,004y + 1,099**	**1,007y + 1,933**	
Expanded relative uncertainty	25 %	**6,0 %**	**6,9 %**	**5,2 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**49**	**49**	**49**	
Calibration		**0,950y -0,026**	**0,944y -0,538**	**0,956y + 0,495**	
Expanded relative uncertainty	25 %	**17,7 %**	**18,5 %**	**17,1 %**	**Pass**
< 100 µg/m^3					
Number of data		**205**	**204**	**205**	
Calibration		**0,858y + 1,919**	**0,842y + 1,621**	**0,865y + 2,336**	
Expanded relative uncertainty	25 %	**10,3 %**	**10,6 %**	**9,6 %**	**Pass**
> 30 µg/m^3					
Number of data		**46**	**45**	**46**	
Calibration		**0,961y -1,951**	**0,956y -2,779**	**0,967y -1,439**	
Expanded relative uncertainty	25 %	**22,9 %**	**23,5 %**	**22,0 %**	**Pass**

Table 5.2: The test results for DustTrak in all the tests for demonstration of equivalence for PM_{10} measurements.

Test PM_{10}	Criteria	DustTrak A + B	DustTrak A	DustTrak B	Pass/Fail
Data capture	≥ 90 % of RM	**100,0 %**	**100,0 %**	**99,4 %**	**Pass**
Suitability of data	20 % > 28 µg/m^3	**Pass**	**Pass**	**Pass**	**Pass**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**5,94**			**Fail**
> 30 µg/m^3	u_{bs} < 2.5 µg/m^3	**2,07**			**Pass**
Test of comparability					
All data					
Number of data		**171**	**171**	**170**	
Slope	Significant	**0,13**	**0,14**	**0,13**	
Intercept	Significant	**10,3**	**8,6**	**12,0**	
Calibrated data					
All data					
Number of data		**171**	**171**	**170**	
Calibration		**7,478y -76,819**	**7,182y -61,667**	**7,808y -93,767**	
Expanded relative uncertainty	25 %	**402,3 %**	**406,8 %**	**408,4 %**	**Fail**
Savilahdentie: Savi 1-1					
Number of data		**45**	**45**	**45**	
Calibration		**1,984y -18,143**	**1,956y -17,541**	**2,009y -18,703**	
Expanded relative uncertainty	25 %	**116,9 %**	**118,2 %**	**115,6 %**	**Fail**
Savilahdentie: Savi 2-2					
Number of data		**44**	**44**	**44**	
Calibration		**9,149y -126,854**	**8,579y -100,982**	**9,800y -156,385**	
Expanded relative uncertainty	25 %	**551,8 %**	**500,2 %**	**618,4 %**	**Fail**
Savilahdentie: Savi 1-3					
Number of data		**41**	**41**	**41**	
Calibration		**7,824y -44,783**	**7,725y -28,415**	**7,918y -61,491**	
Expanded relative uncertainty	25 %	**175,3 %**	**173,6 %**	**183,8 %**	**Fail**
Savilahdentie: Savi 2-4					
Number of data		**41**	**41**	**40**	
Calibration		**0,385y + 6,712**	**0,371y + 7,782**	**0,411y + 5,297**	
Expanded relative uncertainty	25 %	**106,0 %**	**104,4 %**	**102,8 %**	**Fail**
< 100 µg/m^3					
Number of data		**164**	**164**	**163**	
Calibration		**5,761y -55,073**	**5,563y -43,744**	**5,951y -67,193**	
Expanded relative uncertainty	25 %	**1132,0 %**	**1194,7 %**	**1099,9 %**	**Fail**
> 30 µg/m^3					
Number of data		**35**	**35**	**35**	
Calibration		**8,278y -90,352**	**7,964y -74,566**	**8,613y -107,353**	
Expanded relative uncertainty	25 %	**355,9 %**	**365,7 %**	**348,8 %**	**Fail**

Table 5.3: The test results for FH 62 I-R in all the tests for demonstration of equivalence for PM_{10} measurements.

Test PM_{10}	Criteria	FH 62 A + B	FH 62 A	FH 62 B	Pass/Fail
Data capture	≥ 90 % of RM	**91,1 %**	**88,8 %**	**91,1 %**	**Pass**
Suitability of data	20 % > 28 µg/m^3	**Pass**	**Pass**	**Pass**	**Pass**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**2,7**			**Fail**
> 30 µg/m^3	u_{bs} < 2.5 µg/m^3	**5,2**			**Fail**
Test of comparability					
All data					
Number of data		**195**	**190**	**195**	
Slope	Significant	**0,77**	**0,81**	**0,73**	
Intercept	Significant	**0,7**	**0,3**	**1,0**	
Calibrated data					
All data					
Number of data		**195**	**190**	**195**	
Calibration		**1,300y -0,904**	**1,241y -0,321**	**1,363y -1,436**	
Expanded relative uncertainty	25 %	**16,5 %**	**18,3 %**	**15,9 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**51**	**51**	**51**	
Calibration		**1,378y -2,070**	**1,415y -2,924**	**1,328y -0,988**	
Expanded relative uncertainty	25 %	**14,0 %**	**18,7 %**	**12,1 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**50**	**50**	**50**	
Calibration		**1,211y + 0,001**	**1,222y + 0,11**	**1,196y -0,035**	
Expanded relative uncertainty	25 %	**13,6 %**	**16,2 %**	**11,7 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**47**	**42**	**47**	
Calibration		**1,366y -2,081**	**1,286y -1,547**	**1,442y -2,365**	
Expanded relative uncertainty	25 %	**21,1 %**	**22,6 %**	**19,5 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**47**	**47**	**47**	
Calibration		**1,294y -0,067**	**1,237y -0,200**	**1,356y + 0,084**	
Expanded relative uncertainty	25 %	**22,4 %**	**23,6 %**	**21,5 %**	**Pass**
< 100 µg/m^3					
Number of data		**189**	**183**	**188**	
Calibration		**1,372y -1,850**	**1,333y -1,641**	**1,413y -2,120**	
Expanded relative uncertainty	25 %	**17,1 %**	**18,8 %**	**16,2 %**	**Pass**
> 30 µg/m^3					
Number of data		**44**	**44**	**44**	
Calibration		**1,281y + 1,574**	**1,216y + 3,057**	**1,353y -0,040**	
Expanded relative uncertainty	25 %	**21,3 %**	**22,4 %**	**22,6 %**	**Pass**

Table 5.4: The test results for Grimm in all the tests for demonstration of equivalence for PM_{10} measurements.

Test PM_{10}	Criteria	Grimm B + C	Grimm B	Grimm C	Pass/Fail
Data capture	≥ 90 % of RM	**92,7 %**	**92,7 %**	**92,7 %**	**Pass**
Suitability of data	20 % > 28 µg/m^3	**Pass**	**Pass**	**Pass**	**Pass**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**2,09**			**Pass**
> 30 µg/m^3	u_{bs} < 2.5 µg/m^3	**4,48**			**Fail**
Test of comparability					
All data					
Number of data		**179**	**179**	**179**	
Slope	Significant	**1,17**	**1,17**	**1,18**	
Intercept	Significant	**-2,5**	**-2,7**	**-2,4**	
Calibrated data					
All data					
Number of data		**179**	**179**	**179**	
Calibration		**0,855y + 2,139**	**0,788y + 3,02**	**0,850y + 2,075**	
Expanded relative uncertainty	25 %	**17,0 %**	**17,7 %**	**18,0 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**46**	**46**	**46**	
Calibration		**1,024y + 0,74**	**0,958y + 0,643**	**1,091y + 0,965**	
Expanded relative uncertainty	25 %	**10,6 %**	**12,1 %**	**10,7 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**49**	**49**	**49**	
Calibration		**1,561y -3,490**	**1,776y -4,433**	**1,381y -2,653**	
Expanded relative uncertainty	25 %	**21,4 %**	**24,7 %**	**20,2 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**43**	**43**	**43**	
Calibration		**0,778y + 2,329**	**0,768y + 3,053**	**0,784y + 1,671**	
Expanded relative uncertainty	25 %	**16,3 %**	**15,8 %**	**18,9 %**	**Pass**
Savilahdentie: Savi 3					
Number of data		**41**	**41**	**41**	
Calibration		**0,969y + 0,732**	**0,989y + 1,143**	**0,946y + 0,426**	
Expanded relative uncertainty	25 %	**18,7 %**	**18,6 %**	**20,4 %**	**Pass**
< 100 µg/m3					
Number of data		**178**	**178**	**178**	
Calibration		**0,871y + 1,927**	**0,883y + 1,915**	**0,854y + 2,02**	
Expanded relative uncertainty	25 %	**17,0 %**	**17,1 %**	**18,2 %**	**Pass**
> 30 µg/m3					
Number of data		**27**	**27**	**27**	
Calibration		**0,701y + 13,052**	**0,689y + 13,974**	**0,700y + 12,88**	
Expanded relative uncertainty	25 %	**42,4 %**	**43,8 %**	**44,9 %**	**Fail**

Table 5.5: The test results for MP101 in all the tests for demonstration of equivalence for PM_{10} measurements.

Test PM_{10}	Criteria	MP101 A + B	MP101 A	MP101 B	Pass/Fail
Data capture	≥ 90 % of RM	**98,0 %**	**90,7 %**	**97,1 %**	**Pass**
Suitability of data	20 % > 28 µg/m³	**Pass**	**Pass**	**Pass**	**Pass**
Between sampler test					
All data	u_{bs} < 2.5 µg/m³	**2,31**			**Pass**
> 30 µg/m³	u_{bs} < 2.5 µg/m³	**4,32**			**Fail**
Test of comparability					
All data					
Number of data		**201**	**186**	**199**	
Slope	Significant	**1,23**	**1,19**	**1,25**	
Intercept	Significant	**-2,9**	**-2,5**	**-2,8**	
Calibrated data					
All data					
Number of data		**201**	**186**	**199**	
Calibration		**0,811y + 2,311**	**0,838y + 2,102**	**0,800y + 2,242**	
Expanded relative uncertainty	25 %	**11,0 %**	**10,3 %**	**11,6 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**50**	**48**	**49**	
Calibration		**0,897y + 0,486**	**0,918y -0,055**	**0,886y + 0,538**	
Expanded relative uncertainty	25 %	**10,7 %**	**11,0 %**	**10,5 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**52**	**52**	**52**	
Calibration		**1,037y -0,610**	**1,014y -0,395**	**1,059y -0,806**	
Expanded relative uncertainty	25 %	**7,9 %**	**8,0 %**	**8,4 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**49**	**40**	**49**	
Calibration		**0,974y -0,687**	**0,975y -0,663**	**0,985y -0,794**	
Expanded relative uncertainty	25 %	**8,0 %**	**8,1 %**	**9,8 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**50**	**46**	**49**	
Calibration		**0,803y + 2,371**	**0,828y + 2,869**	**0,794y + 1,457**	
Expanded relative uncertainty	25 %	**12,4 %**	**12,3 %**	**11,5 %**	**Pass**
< 100 µg/m³					
Number of data		**194**	**180**	**193**	
Calibration		**0,887y + 0,826**	**0,910y + 0,64**	**0,860y + 1,086**	
Expanded relative uncertainty	25 %	**9,4 %**	**8,9 %**	**11,1 %**	**Pass**
> 30 µg/m³					
Number of data		**47**	**46**	**46**	
Calibration		**0,788y + 6,223**	**0,815y + 5,547**	**0,776y + 6,13**	
Expanded relative uncertainty	25 %	**13,5 %**	**12,8 %**	**15,2 %**	**Pass**

Table 5.6: The test results for Osiris in all the tests for demonstration of equivalence for PM_{10} measurements.

Test PM_{10}	Criteria	Osiris A + B	Osiris A	Osiris B	Pass/Fail
Data capture	≥ 90 % of RM	**95,3 %**	**95,0 %**	**95,3 %**	**Pass**
Suitability of data	20 % > 28 µg/m^3	**Pass**	**Pass**	**Pass**	**Pass**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**2,63**			**Fail**
> 30 µg/m^3	u_{bs} < 2.5 µg/m^3	**5,92**			**Fail**
Test of comparability					
All data					
Number of data		**284**	**283**	**284**	
Slope	Significant	**0,71**	**0,74**	**0,69**	
Intercept	Significant	**0,1**	**-0,3**	**0,5**	
Calibrated data					
All data					
Number of data		**284**	**283**	**284**	
Calibration		**1,401y -0,153**	**1,346y + 0,462**	**1,456y -0,795**	
Expanded relative uncertainty	25 %	**15,7 %**	**17,3 %**	**18,8 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**51**	**52**	**51**	
Calibration		**1,144y + 1,862**	**1,219y + 2,359**	**1,067y + 1,624**	
Expanded relative uncertainty	25 %	**12,1 %**	**11,4 %**	**14,1 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**50**	**50**	**50**	
Calibration		**1,228y + 0,528**	**1,276y + 1,142**	**1,182y -0,023**	
Expanded relative uncertainty	25 %	**9,1 %**	**8,6 %**	**9,9 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**49**	**48**	**49**	
Calibration		**1,948y -0,394**	**2,046y -0,805**	**1,855y -0,005**	
Expanded relative uncertainty	25 %	**14,4 %**	**14,5 %**	**15,0 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**51**	**51**	**51**	
Calibration		**1,396y + 2,573**	**1,340y + 3,468**	**1,456y + 1,624**	
Expanded relative uncertainty	25 %	**18,1 %**	**20.7%**	**18,6 %**	**Pass**
Savilahdentie: Savi 3					
Number of data		**40**	**40**	**41**	
Calibration		**1,327y + 1,042**	**1,184y + 0,991**	**1,488y + 0,882**	
Expanded relative uncertainty	25 %	**9,6 %**	**9,2 %**	**9,4 %**	**Pass**
Savilahdentie: Savi 4					
Number of data		**43**	**42**	**42**	
Calibration		**0,886y + 2,559**	**0,699y + 3,249**	**1,197y + 1,494**	
Expanded relative uncertainty	25 %	**16,9 %**	**21,3 %**	**14,8 %**	**Pass**
< 100 µg/m^3					
Number of data		**277**	**276**	**277**	
Calibration		**1,338y + 0,57**	**1,294y + 1,058**	**1,360y + 0,308**	
Expanded relative uncertainty	25 %	**15,3 %**	**17,1 %**	**17,7 %**	**Pass**
> 30 µg/m^3					
Number of data		**48**	**48**	**48**	
Calibration		**1,415y -1,367**	**1,342y + 1**	**1,494y -4,109**	
Expanded relative uncertainty	25 %	**24,7 %**	**26,9 %**	**31,3 %**	**Fail**

Table 5.7: The test results for Sharp beta in all the tests for demonstration of equivalence for PM_{10} measurements.

Test PM_{10}	Criteria	Sharp beta A + B	Sharp beta A	Sharp beta B	Pass/Fail
Data capture	≥ 90 % of RM	**99,0 %**	**96,6 %**	**98,5 %**	**Pass**
Suitability of data	20 % > 28 µg/m^3	**Pass**	**Pass**	**Pass**	**Pass**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**1,28**			**Pass**
> 30 µg/m^3	u_{bs} < 2.5 µg/m^3	**2,26**			**Pass**
Test of comparability					
All data					
Number of data		**203**	**198**	**202**	
Slope	Significant	**0,71**	**0,72**	**0,69**	
Intercept	Significant	**1,6**	**1,5**	**1,9**	
Calibrated data					
All data					
Number of data		**203**	**198**	**202**	
Calibration		**1,415y -2,233**	**1,394y -2,063**	**1,439y -2,607**	
Expanded relative uncertainty	25 %	**12,8 %**	**11,2 %**	**13,7 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**51**	**50**	**50**	
Calibration		**1,471y -2,871**	**1,488y -3,288**	**1,451y -2,375**	
Expanded relative uncertainty	25 %	**6,2 %**	**6,2 %**	**7,6 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**52**	**52**	**52**	
Calibration		**1,194y -0,642**	**1,224y -0,568**	**1,163y -0,681**	
Expanded relative uncertainty	25 %	**7,2 %**	**7,7 %**	**7,6 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**49**	**47**	**49**	
Calibration		**1,803y -5,429**	**1,706y -4,788**	**1,734y -4,849**	
Expanded relative uncertainty	25 %	**11,6 %**	**10,7 %**	**11,0 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**51**	**49**	**51**	
Calibration		**1,405y -1,105**	**1,387y -1,554**	**1,430y -1,067**	
Expanded relative uncertainty	25 %	**16,3 %**	**15,6 %**	**16,9 %**	**Pass**
< 100 µg/m^3					
Number of data		**197**	**193**	**196**	
Calibration		**1,489y -3,301**	**1,450y -2,879**	**1,498y -3,456**	
Expanded relative uncertainty	25 %	**12,5 %**	**10,6 %**	**13,5 %**	**Pass**
> 30 µg/m^3					
Number of data		**47**	**44**	**47**	
Calibration		**1,396y + 0,002**	**1,376y -0,081**	**1,427y -1,084**	
Expanded relative uncertainty	25 %	**23,5 %**	**20,1 %**	**24,8 %**	**Pass**

Table 5.8: The test results for Sharp c-dust in all the tests for demonstration of equivalence for PM_{10} measurements.

Test PM_{10}	Criteria	Sharp c-dust A + B	Sharp c-dust A	Sharp c-dust B	Pass/Fail
Data capture	≥ 90 % of RM	**96,1 %**	**91,2 %**	**95,6 %**	**Pass**
Suitability of data	20 % > 28 µg/m^3	**Pass**	**Pass**	**Pass**	**Pass**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**1,60**			**Pass**
> 30 µg/m^3	u_{bs} < 2.5 µg/m^3	**3,10**			**Fail**
Test of comparability					
All data					
Number of data		**197**	**187**	**196**	
Slope	Significant	**0,71**	**0,74**	**0,70**	
Intercept	Significant	**2,0**	**1,6**	**2,2**	
Calibrated data					
All data					
Number of data		**197**	**187**	**196**	
Calibration		**1,404y -2,750**	**1,344y -2,104**	**1,431y -3,130**	
Expanded relative uncertainty	25 %	**17,2 %**	**14,7 %**	**17,5 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**49**	**45**	**48**	
Calibration		**1,553y -4,890**	**1,558y -5,233**	**1,510y -3,780**	
Expanded relative uncertainty	25 %	**17,8 %**	**22,3 %**	**17,3 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**52**	**52**	**52**	
Calibration		**1,175y -0,678**	**1,208y -0,745**	**1,142y -0,585**	
Expanded relative uncertainty	25 %	**9,9 %**	**10,6 %**	**9,8 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**47**	**46**	**47**	
Calibration		**1,648y -4,554**	**1,477y -3,395**	**1,635y -4,364**	
Expanded relative uncertainty	25 %	**12,8 %**	**12,5 %**	**14,3 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**49**	**44**	**49**	
Calibration		**1,401y -2,273**	**1,340y -2,082**	**1,431y -2,535**	
Expanded relative uncertainty	25 %	**26,0 %**	**18,6 %**	**25,0 %**	**Pass**
< 100 µg/m^3					
Number of data		**191**	**184**	**190**	
Calibration		**1,486y -3,904**	**1,400y -2,891**	**1,479y -3,770**	
Expanded relative uncertainty	25 %	**16,5 %**	**15,1 %**	**17,1 %**	**Pass**
> 30 µg/m^3					
Number of data		**41**	**34**	**41**	
Calibration		**1,385y -0,174**	**1,319y + 1,074**	**1,423y -1,638**	
Expanded relative uncertainty	25 %	**30,3 %**	**23,4 %**	**30,3 %**	**Fail**

Table 5.9: The test results for TEOM in all the tests for demonstration of equivalence for PM_{10} measurements.

Test PM_{10}	Criteria	TEOM A + B	TEOM A	TEOM B	Pass/Fail
Data capture	≥ 90 % of RM	**94,6 %**	**89,8 %**	**94,6 %**	**Pass**
Suitability of data	20 % > 28 µg/m^3	**Pass**	**Pass**	**Pass**	**Pass**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**1,83**			**Pass**
> 30 µg/m^3	u_{bs} < 2.5 µg/m^3	**3,38**			**Fail**
Test of comparability					
All data					
Number of data		**194**	**184**	**194**	
Slope	Significant	**1,15**	**1,17**	**1,13**	
Intercept	Significant	**2,4**	**2,3**	**2,5**	
Calibrated data					
All data					
Number of data		**194**	**184**	**194**	
Calibration		**0,868y -2,068**	**0,852y -1,981**	**0,884y -2,215**	
Expanded relative uncertainty	25 %	**14,4 %**	**13,9 %**	**15,2 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**48**	**48**	**48**	
Calibration		**0,730y + 0,161**	**0,715y + 0,223**	**0,745y + 0,135**	
Expanded relative uncertainty	25 %	**14,3 %**	**13,9 %**	**14,9 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**48**	**48**	**48**	
Calibration		**0,881y -1,222**	**0,875y -1,363**	**0,888y -1,071**	
Expanded relative uncertainty	25 %	**9,2 %**	**9,7 %**	**8,7 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**48**	**46**	**48**	
Calibration		**1,064y -3,287**	**1,031y -3,006**	**1,099y -3,617**	
Expanded relative uncertainty	25 %	**8,7 %**	**9,9 %**	**7,9 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**50**	**42**	**50**	
Calibration		**0,873y -2,912**	**0,857y -2,621**	**0,891y -3,414**	
Expanded relative uncertainty	25 %	**18,1 %**	**16,8 %**	**20,2 %**	**Pass**
< 100 µg/m^3					
Number of data		**187**	**177**	**187**	
Calibration		**0,804y -0,623**	**0,792y -0,600**	**0,813y -0,604**	
Expanded relative uncertainty	25 %	**13,6 %**	**13,4 %**	**14,0 %**	**Fail**
> 30 µg/m^3					
Number of data		**44**	**41**	**44**	
Calibration		**0,878y -3,541**	**0,861y -3,236**	**0,896y -3,853**	
Expanded relative uncertainty	25 %	**26,8 %**	**26,3 %**	**28,2 %**	**Fail**

5.1.4 Summary of the PM_{10} comparisons

The number of sites and the number of campaigns cover the requirements of the GDE for PM_{10} comparison tests. The meteorological conditions over the campaigns periods represents the annual variation met in southern Finland. The concentration ranges at both sites in Kuopio were satisfactory, fulfilling the suitability concentration criterion defined by the GDE. During the episode situation in late winter, the PM_{10} concentrations exceeded the limit values at Savilahdentie where the daily concentrations reached 300 µg/m^3, which was an exceptionally high concentration. The episode, mainly caused by the resuspended sand particles, lasted from the 9th to 18th in March 2015. The chemical content of the sand particles during the episode was rather homogeneous including mostly silica. This has an influence on some of the CM e.g. those using the optical method, since the refraction index and density can be different from the particles that are used for the calibration of the instrument. The exceptional episode was also the reason to provide an additional range from 0 to 100 µg/m^3 for the calibration equations for the CMs. As seen from Figure 5.3 the range up to 100 µg/m^3 excludes the data only from the episode period leaving most of the data still in the data analysis. In most of the cases the uncertainty of the measurement results is the same or slightly decreased and only minor change for the slope occurs if any. One should also keep in mind that the scope of the reference method according to EN 12341 is from 0 to 150 µg/m^3 for PM_{10}.

During the PM_{10} comparison the CMs were functioning reasonably well. The one Grimm instrument was delayed from the beginning of the campaign due to the calibration of the instrument at the manufacturer, which was the cause to discard the first campaign of Tasa 1 for Grimm (see table 5.4). Also one of the meteorological sensors of Grimm went out of order causing a short period of lack of data.

To have a better view over the for PM_{10} concentration ranges the monthly mean PM_{10} concentrations from different parts in Finland together with the values obtained in this comparison are presented in Figure 5.5.

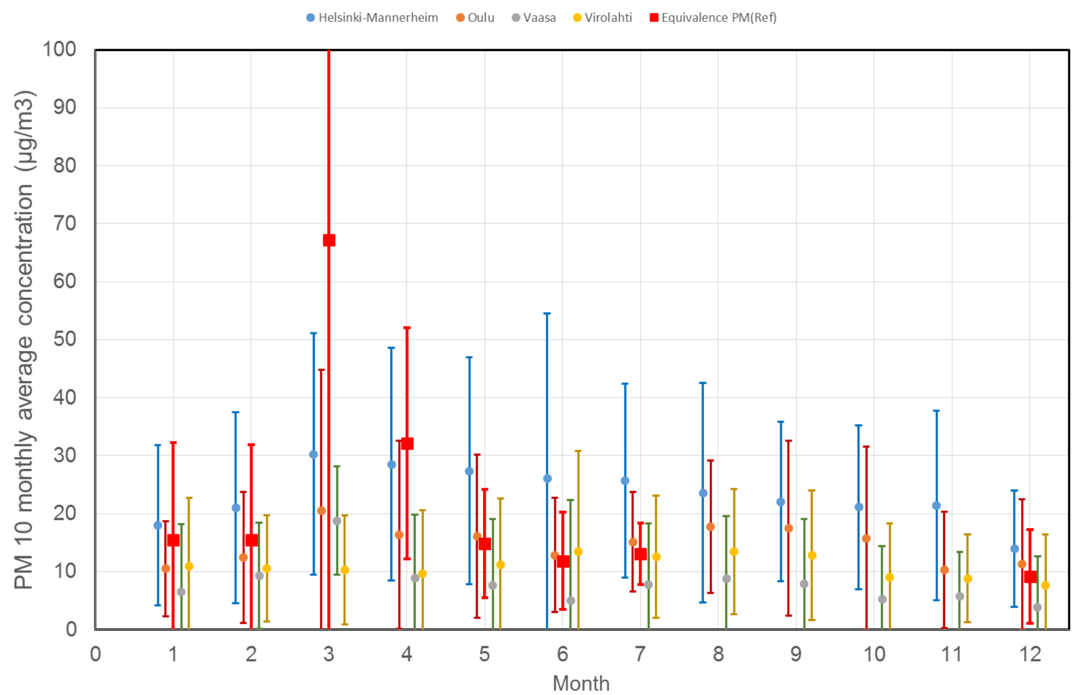

Figure 5.5: The monthly mean concentration of PM_{10} in 2014-15 in Helsinki (blue dot), in Oulu (orange dot), in Vaasa (grey dot), background station in Virolahti (brown dot), and in the PM_{10} equivalence tests (red square) in Kuopio.

Figure 5.5 shows that the concentration ranges from the comparison joins very well with the concentration ranges at different sites across Finland in spite of lack of data during the months in autumn.

Regarding the results for demonstration of equivalence, Tables 5.1 to 5.9, the data capture should be 90% of the reference method. This requirement is fulfilled with every CM except for FH 62 A which has a data capture of 89 % of the RM. Suitability requirement is fulfilled by all CMs. Between the CM, a test is performed to all data and to data with the concentration above 30 µg/m^3. The BAM and SHARP β-signals completely fulfilled this requirement. The Grimm, MP101, SHARP C-dust signal and the TEOM passed the requirement for all data, but failed with the data where the concentration was above 30 µg/m^3. The DustTrak, FH 62 and Osiris failed with both of the requirements. The additional range between 0 to 100 µg/m^3 was analyzed in order to represent better the concentration ranges met in Finland. Test of comparability (see in Chapter 2.4 and 4.2) indicates that the correction of the data with the calibration equation needs to apply for all CMs.

5.3. Results of the $PM_{2.5}$ comparisons

The comparison tests for the CMs of $PM_{2.5}$ measurements continued with summer and autumn comparisons at Tasavallankatu. At Savilahdentie the comparison started at the beginning of December. As mentioned earlier the measurement strategy changed at Savilahdentie with respect to the use of the reference method. One of the reference samplers was sampling PM_{10} and the other $PM_{2.5}$ continuously. There was a short period for parallel measurement of PM_{10} at the beginning of the campaigns at Savilahdentie to demonstrate that the samplers are equal.

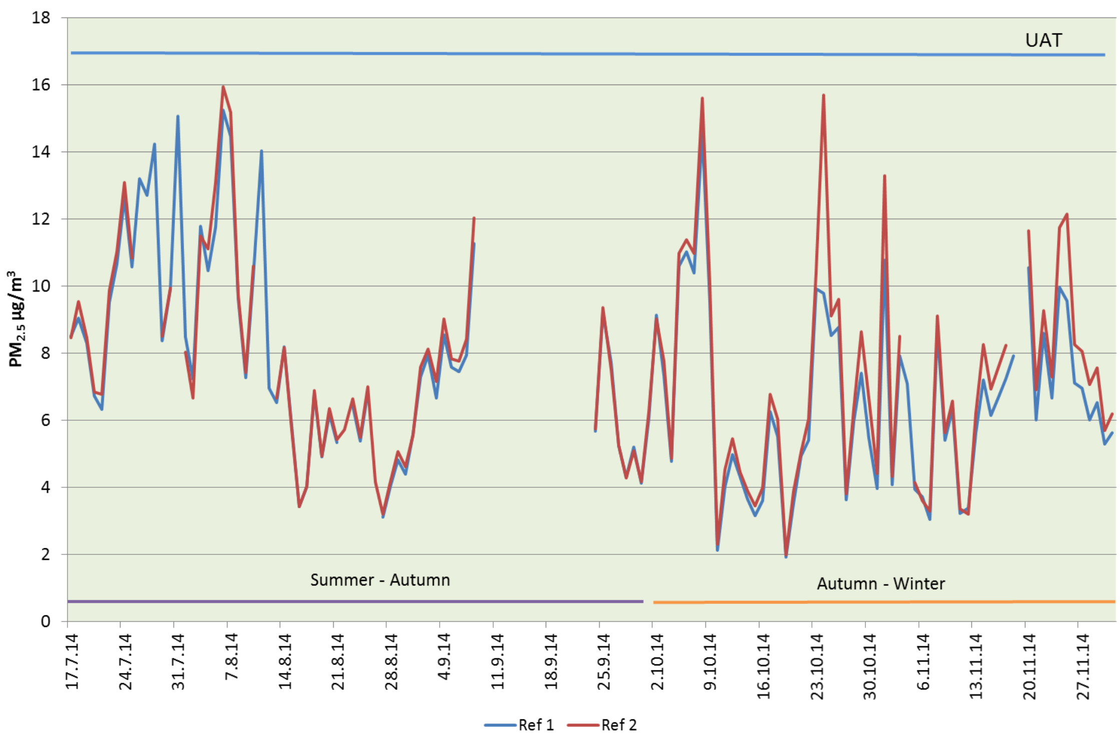

Figure 5.8a: The time series of the two RMs for $PM_{2.5}$ comparisons from Tasavallankatu. UAT is the annual upper assessment threshold value for $PM_{2.5}$.

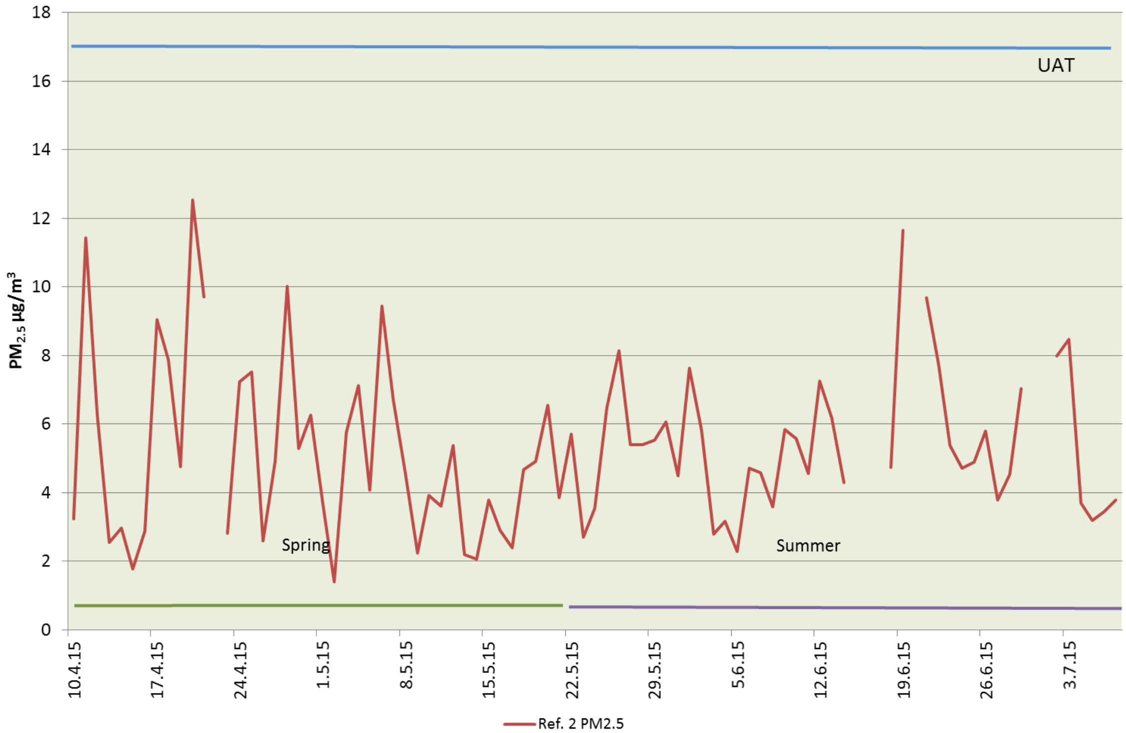

Figure 5.8b. The time series of the two RMs for $PM_{2.5}$ comparisons from Savilahdentie. UAT is the annual upper assessment threshold value for $PM_{2.5}$.

In Figure 5.8 the time series of daily concentrations of RMs for $PM_{2.5}$ for campaigns at Tasavallankatu (5.8a) and at Savilahdentie (5.8b) are presented. In the figure the annual Upper Assessment Threshold value is 17 µg/m^3 showing that all the concentration values for $PM_{2.5}$ are less than that. At Savilahdentie the concentrations are even lower than at Tasavallankatu while for PM_{10} the situation was opposite.

The scatterplot of RM2 against the RM1 is presented in Figure 5.9 from the campaigns in Tasavallankatu. The standard uncertainty for the between sampler test for the reference method, according to eq. (2.1), is 0.6 µg/m^3 for all data.

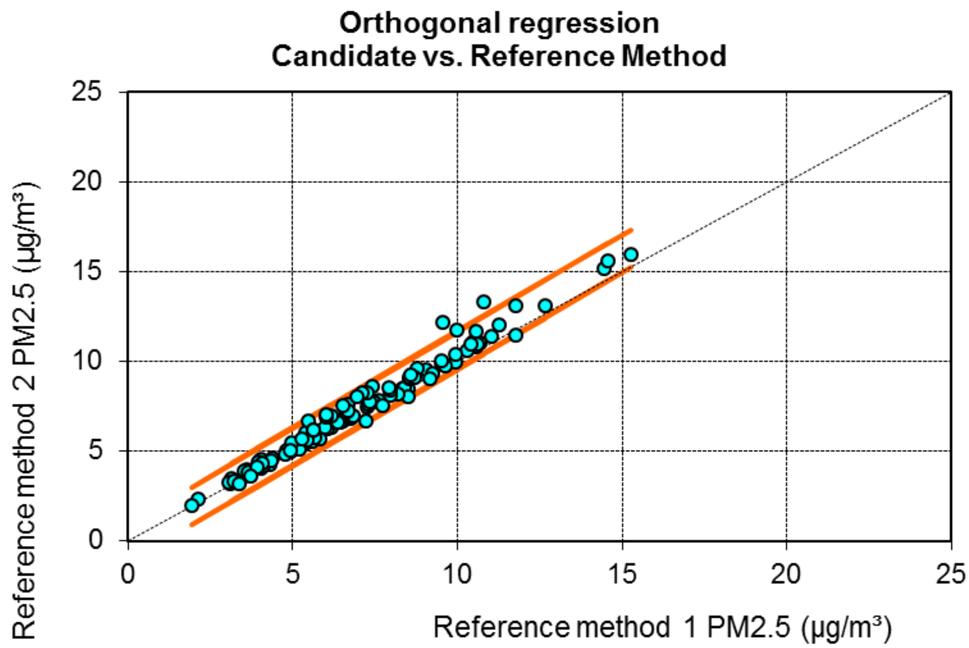

Figure 5.9: The scatter plot of the RM2 against the RM1 for $PM_{2.5}$ from Tasavallankatu.

5.3.3. Results of the candidate methods for $PM_{2.5}$

In the following tables all the results for the analysis of the CMs against the RM are presented. The analysis is the same as in PM_{10} including the data capture, suitability of data, between CM tests and comparability test. The comparability test includes the tests of significance for slope and intercept indicating if the calibration function for CM is required. The comparability tests are performed for each of the campaigns. The calibration equation according to Eq. (2.8a) is expressed in any case i.e. irrespectively if the slope *b* and/or *a* are significantly different from 1 and 0, respectively. The analysis of data for larger than 18 µg/m^3 was not performed as required by the GDE due to the fact there were no many days fulfilling this requirement as seen in the figure 5.8. The results that exceeds the acceptable limit, see in chapter 2.4, are printed in red color.

Table 5.10: The test results of BAM for all the tests for demonstration of equivalence for $PM_{2.5}$ measurements.

Test $PM_{2.5}$	Criteria	BAM A + B	BAM A	BAM B	Pass/Fail
Data capture	≥ 90 % of RM	**95,1 %**	**84,4 %**	**95,1 %**	**Pass**
Suitability of data	20 % > 17 µg/m^3	**Fail**	**Fail**	**Fail**	**Fail**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**0,64**			**Pass**
> 18 µg/m^3	u_{bs} < 2.5 µg/m^3				
Test of comparability					
All data					
Number of data		**195**	**173**	**195**	
Slope	Significant	**0,91**	**0,95**	**0,98**	
Intercept	Significant	**-0,7**	**-0,8**	**-1,9**	
Calibrated data					
All data					
Number of data		**195**	**173**	**195**	
Calibration		**1,100y + 0,733**	**1,058y + 0,883**	**1,016y + 1,934**	
Expanded relative uncertainty	25 %	**7,4 %**	**7,3 %**	**6,8 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**59**	**52**	**59**	
Calibration		**1,124y + 1,31**	**1,120y + 0,868**	**1,112y + 1,762**	
Expanded relative uncertainty	25 %	**0,3 %**	**3,3 %**	**1,8 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**56**	**50**	**56**	
Calibration		**0,919y + 1,521**	**0,930y + 1,176**	**0,915y + 1,813**	
Expanded relative uncertainty	25 %	**7,9 %**	**13,2 %**	**8,2 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**40**	**40**	**40**	
Calibration		**1,320y -0,597**	**1,339y + 0,051**	**1,291y + 1,41**	
Expanded relative uncertainty	25 %	**21,4 %**	**23,0 %**	**20,6 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**40**	**31**	**40**	
Calibration		**0,823y + 1,672**	**0,929y + 1,374**	**0,820y + 2,74**	
Expanded relative uncertainty	25 %	**22,2 %**	**14,3 %**	**21,6 %**	**Pass**

Table 5.11. The test results of DustTrak for all the tests for demonstration of equivalence for $PM_{2.5}$ measurements.

Test $PM_{2.5}$	Criteria	DustTrak A + B	DustTrak A	DustTrak B	Pass/Fail
Data capture	≥ 90 % of RM	**98,2 %**	**98,2 %**	**97,6 %**	**Pass**
Suitability of data	20 % > 17 µg/m^3	**Fail**	**Fail**	**Fail**	**Fail**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**2,88**			**Fail**
> 18 µg/m^3	u_{bs} < 2.5 µg/m^3				
Test of comparability					
All data					
Number of data		**164**	**164**	**163**	
Slope	Significant	**1,66**	**2,03**	**1,56**	
Intercept	Significant	**1,7**	**-2,4**	**4,2**	
Calibrated data					
All data					
Number of data		**164**	**164**	**163**	
Calibration		**0,602y -1,002**	**0,492y + 1,19**	**0,641y -2,685**	
Expanded relative uncertainty	25 %	**37,9 %**	**48,8 %**	**35,0 %**	**Fail**
Savilahdentie: Savi 1-1					
Number of data		**43**	**43**	**43**	
Calibration		**0,340y + 0,469**	**0,330y + 0,758**	**0,348y + 0,196**	
Expanded relative uncertainty	25 %	**36,3 %**	**38,1 %**	**35,4 %**	**Fail**
Savilahdentie: Savi 2-2					
Number of data		**40**	**40**	**40**	
Calibration		**0,957y -6,944**	**0,923y -4,444**	**0,991y -9,588**	
Expanded relative uncertainty	25 %	**53,0 %**	**53,0 %**	**53,1 %**	**Fail**
Savilahdentie: Savi 1-3					
Number of data		**40**	**40**	**40**	
Calibration		**0,551y + 0,491**	**0,547y + 1,726**	**0,535y -0,520**	
Expanded relative uncertainty	25 %	**48,3 %**	**50,0 %**	**50,8 %**	**Fail**
Savilahdentie: Savi 2-4					
Number of data		**41**	**41**	**40**	
Calibration		**0,303y + 2,708**	**0,289y + 3,577**	**0,320y + 1,678**	
Expanded relative uncertainty	25 %	**61,7 %**	**64,1 %**	**58,6 %**	**Fail**

Table 5.12. The test results of FH 62 I-R for all the tests for demonstration of equivalence for $PM_{2.5}$ measurements.

Test $PM_{2.5}$	Criteria	FH 62 A + B	FH 62 A	FH 62 B	Pass/Fail
Data capture	≥ 90 % of RM	**95,1 %**	**92,2 %**	**95,1 %**	**Pass**
Suitability of data	20 % > 17 µg/m³	**Fail**	**Fail**	**Fail**	**Fail**
Between sampler test					
All data	u_{bs} < 2.5 µg/m³	**1,07**			**Pass**
> 18 µg/m³	u_{bs} < 2.5 µg/m³				
Test of comparability					
All data					
Number of data		**195**	**189**	**195**	
Slope	Significant	**1,18**	**1,38**	**1,06**	
Intercept	Significant	**-2,0**	**-3,1**	**-1,6**	
Calibrated data					
All data					
Number of data		**195**	**189**	**195**	
Calibration		**0,850y + 1,709**	**0,722y + 2,227**	**0,940y + 1,488**	
Expanded relative uncertainty	25 %	**17,3 %**	**24,6 %**	**15,0 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**57**	**54**	**59**	
Calibration		**0,919y + 1,801**	**0,737y + 2,811**	**1,041y + 1,359**	
Expanded relative uncertainty	25 %	**16,7 %**	**23,9 %**	**15,2 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**56**	**54**	**56**	
Calibration		**0,881y + 1,796**	**0,790y + 2,229**	**0,929y + 1,49**	
Expanded relative uncertainty	25 %	**16,4 %**	**21,0 %**	**11,9 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**41**	**41**	**40**	
Calibration		**0,814y + 1,503**	**0,647y + 1,902**	**0,988y + 1,125**	
Expanded relative uncertainty	25 %	**42,5 %**	**58,4 %**	**34,6 %**	**Fail**
Savilahdentie: Savi 2					
Number of data		**41**	**40**	**40**	
Calibration		**0,415y + 3,173**	**0,401y + 3,2**	**0,487y + 3,121**	
Expanded relative uncertainty	25 %	**78,9 %**	**81,1 %**	**70,6 %**	**Fail**

Table 5.13. The test results of Grimm for all the tests for demonstration of equivalence for $PM_{2.5}$ measurements.

Test $PM_{2.5}$	Criteria	Grimm B + C	Grimm B	Grimm C	Pass/Fail
Data capture	≥ 90 % of RM	**96,1 %**	**94,4 %**	**93,9 %**	**Pass**
Suitability of data	20 % > 17 µg/m³	**Fail**	**Fail**	**Fail**	**Fail**
Between sampler test					
All data	u_{bs} < 2.5 µg/m³	**0,60**			**Pass**
> 18 µg/m³	u_{bs} < 2.5 µg/m³				
Test of comparability					
All data					
Number of data		**173**	**170**	**169**	
Slope	Significant	**1,34**	**1,39**	**1,36**	
Intercept	Significant	**-0,7**	**-1,0**	**-0,7**	
Calibrated data					
All data					
Number of data		**173**	**170**	**169**	
Calibration		**0,747y + 0,532**	**0,718y + 0,735**	**0,737y + 0,536**	
Expanded relative uncertainty	25 %	**12,6 %**	**11,9 %**	**13,8 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**50**	**47**	**46**	
Calibration		**1,019y -0,854**	**0,983y -0,926**	**1,087y -0,985**	
Expanded relative uncertainty	25 %	**10,4 %**	**11,5 %**	**10,2 %**	**Pass**
Savilahdentie: Savi 1-1					
Number of data		**43**	**43**	**43**	
Calibration		**0,730y + 0,25**	**0,703y + 0,549**	**0,747y + 0,023**	
Expanded relative uncertainty	25 %	**11,5 %**	**10,0 %**	**14,9 %**	**Pass**
Savilahdentie: Savi 2-2					
Number of data		**40**	**40**	**40**	
Calibration		**0,745y -0,159**	**0,717y + 0,122**	**0,739y -0,345**	
Expanded relative uncertainty	25 %	**24,2 %**	**23,4 %**	**24,4 %**	**Pass**
Savilahdentie: Savi 1-3					
Number of data		**40**	**40**	**40**	
Calibration		**0,718y + 0,571**	**0,735y + 0,652**	**0,701y + 0,497**	
Expanded relative uncertainty	25 %	**16,3 %**	**16,6 %**	**16,1 %**	**Pass**

Table 5.14. The test results of MP101 for all the tests for demonstration of equivalence for $PM_{2.5}$ measurements.

Test $PM_{2.5}$	Criteria	MP101 A + B	MP101 A	MP101 B	Pass/Fail
Data capture	≥ 90 % of RM	**95,6 %**	**93,7 %**	**95,1 %**	**Pass**
Suitability of data	20 % > 17 µg/m^3	**Fail**	**Fail**	**Fail**	**Fail**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**1,25**			**Pass**
> 18 µg/m^3	u_{bs} < 2.5 µg/m^3				
Test of comparability					
All data					
Number of data		**196**	**192**	**195**	
Slope	Significant	**1,23**	**1,12**	**1,31**	
Intercept	Significant	**0,4**	**0,6**	**0,3**	
Calibrated data					
All data					
Number of data		**196**	**192**	**195**	
Calibration		**0,812y -0,306**	**0,894y -0,517**	**0,763y -0,266**	
Expanded relative uncertainty	25 %	**8,9 %**	**9,7 %**	**9,4 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**57**	**56**	**57**	
Calibration		**0,876y -0,901**	**0,950y -0,623**	**0,824y -1,196**	
Expanded relative uncertainty	25 %	**10,8 %**	**12,4 %**	**14,6 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**57**	**56**	**57**	
Calibration		**0,873y -0,924**	**0,867y -0,728**	**0,836y -0,802**	
Expanded relative uncertainty	25 %	**15,6 %**	**18,4 %**	**16,7 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**40**	**40**	**40**	
Calibration		**0,701y + 0,251**	**0,847y -0,260**	**0,735y -0,123**	
Expanded relative uncertainty	25 %	**22,6 %**	**18,5 %**	**18,6 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**42**	**40**	**41**	
Calibration		**0,762y + 0,291**	**0,856y -0,142**	**0,672y + 0,624**	
Expanded relative uncertainty	25 %	**22,0 %**	**21,5 %**	**21,5 %**	**Pass**

Table 5.15: The test results of Osiris for all the tests for demonstration of equivalence for $PM_{2.5}$ measurements.

Test $PM_{2.5}$	Criteria	Osiris A + B	Osiris A	Osiris B	Pass/Fail
Data capture	≥ 90 % of RM	**95,1 %**	**94,6 %**	**95,1 %**	**Pass**
Suitability of data	20 % > 17 µg/m³	**Fail**	**Fail**	**Fail**	**Fail**
Between sampler test					
All data	u_{bs} < 2.5 µg/m³	**0,31**			**Pass**
> 18 µg/m³	u_{bs} < 2.5 µg/m³				
Test of comparability					
All data					
Number of data		**195**	**194**	**195**	
Slope	Significant	**0,30**	**0,31**	**0,30**	
Intercept	Significant	**0,3**	**0,1**	**0,5**	
Calibrated data					
All data					
Number of data		**195**	**194**	**195**	
Calibration		**3,324y -1,073**	**3,278y -0,429**	**3,331y -1,662**	
Expanded relative uncertainty	25 %	**124,2 %**	**115,0 %**	**134,9 %**	**Fail**
Tasavallankatu: Tasa 1					
Number of data		**61**	**61**	**61**	
Calibration		**5,498y -5,562**	**4,854y -3,187**	**6,318y -8,607**	
Expanded relative uncertainty	25 %	**187,0 %**	**132,2 %**	**296,0 %**	**Fail**
Tasavallankatu: Tasa 2					
Number of data		**51**	**51**	**51**	
Calibration		**3,641y -4,824**	**3,654y -4,450**	**3,622y -5,172**	
Expanded relative uncertainty	25 %	**112,7 %**	**101,0 %**	**127,3 %**	**Fail**
Savilahdentie: Savi 1					
Number of data		**41**	**40**	**41**	
Calibration		**1,881y + 1,36**	**1,928y + 1,467**	**1,738y + 1,357**	
Expanded relative uncertainty	25 %	**24,7 %**	**20,3 %**	**22,6 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**42**	**42**	**42**	
Calibration		**6,505y -2,357**	**8,562y -2,529**	**5,178y -2,155**	
Expanded relative uncertainty	25 %	**411,9 %**	**519,6 %**	**343,6 %**	**Fail**

Table 5.16. The test results of SHARP beta for all the tests for demonstration of equivalence for $PM_{2.5}$ measurements.

Test $PM_{2.5}$	Criteria	Sharp beta A + B	Sharp beta A	Sharp beta B	Pass/Fail
Data capture	≥ 90 % of RM	**95,6 %**	**96,1 %**	**93,2 %**	**Pass**
Suitability of data	20 % > 17 μg/m^3	**Fail**	**Fail**	**Fail**	**Fail**
Between sampler test					
All data	u_{bs} < 2.5 μg/m^3	**0,58**			**Pass**
> 18 μg/m^3	u_{bs} < 2.5 μg/m^3				
Test of comparability					
All data					
Number of data		**196**	**197**	**191**	
Slope		**1,03**	**1,04**	**1,04**	
Intercept		**0,0**	**0,0**	**-0,1**	
Calibrated data					
All data					
Number of data		**196**	**197**	**191**	
Calibration		**0,971y -0,003**	**0,966y + 0,002**	**0,959y + 0,127**	
Expanded relative uncertainty	25 %	**0,2 %**	**0,2 %**	**3,9 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**57**	**58**	**54**	
Calibration		**0,970y + 0,047**	**0,957y + 0,181**	**0,942y + 0,199**	
Expanded relative uncertainty	25 %	**2,3 %**	**2,7 %**	**7,4 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**57**	**57**	**57**	
Calibration		**0,975y -0,103**	**0,947y -0,097**	**0,988y + 0,008**	
Expanded relative uncertainty	25 %	**4,3 %**	**6,3 %**	**5,8 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**40**	**40**	**40**	
Calibration		**1,132y -0,564**	**1,165y -0,688**	**1,073y -0,304**	
Expanded relative uncertainty	25 %	**11,0 %**	**9,7 %**	**14,5 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**42**	**42**	**40**	
Calibration		**0,828y + 0,635**	**0,877y + 0,398**	**0,848y + 0,593**	
Expanded relative uncertainty	25 %	**13,4 %**	**9,6 %**	**16,9 %**	**Pass**

Table 5.17. The test results of SHARP c-dust for all the tests for demonstration of equivalence for $PM_{2.5}$ measurements.

Test $PM_{2.5}$	Criteria	Sharp c-dust A + B	Sharp c-dust A	Sharp c-dust B	Pass/Fail
Data capture	≥ 90 % of RM	**95,1 %**	**94,6 %**	**92,7 %**	**Pass**
Suitability of data	20 % > 17 µg/m^3	**Fail**	**Fail**	**Fail**	**Fail**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**1,68**			**Pass**
> 18 µg/m^3	u_{bs} < 2.5 µg/m^3				
Test of comparability					
All data					
Number of data		**195**	**194**	**190**	
Slope	Significant	**1,17**	**1,38**	**1,11**	
Intercept	Significant	**-1,4**	**-3,2**	**-0,6**	
Calibrated data					
All data					
Number of data		**195**	**194**	**190**	
Calibration		**0,854y + 1,187**	**0,726y + 2,328**	**0,900y + 0,559**	
Expanded relative uncertainty	25 %	**7,3 %**	**16,2 %**	**5,9 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**58**	**58**	**53**	
Calibration		**0,978y + 0,127**	**0,927y + 0,726**	**0,986y -0,085**	
Expanded relative uncertainty	25 %	**7,2 %**	**12,2 %**	**5,7 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**57**	**53**	**57**	
Calibration		**0,908y + 0,397**	**0,855y + 0,62**	**0,943y + 0,317**	
Expanded relative uncertainty	25 %	**9,9 %**	**13,8 %**	**9,2 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**40**	**41**	**40**	
Calibration		**0,953y + 0,709**	**1,046y + 0,498**	**0,872y + 0,984**	
Expanded relative uncertainty	25 %	**14,5 %**	**17,2 %**	**18,7 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**40**	**42**	**40**	
Calibration		**0,644y + 2,763**	**0,469y + 4,314**	**0,681y + 1,394**	
Expanded relative uncertainty	25 %	**27,7 %**	**65,8 %**	**18,7 %**	**Fail**

Table 5.18. The test results of TEOM for all the tests for demonstration of equivalence for $PM_{2.5}$ measurements.

Test $PM_{2.5}$	Criteria	TEOM A + B	TEOM A	TEOM B	Pass/Fail
Data capture	≥ 90 % of RM	**95,6 %**	**95,1 %**	**95,6 %**	**Pass**
Suitability of data	20 % > 17 µg/m^3	**Fail**	**Fail**	**Fail**	**Fail**
Between sampler test					
All data	u_{bs} < 2.5 µg/m^3	**0,42**			**Pass**
> 18 µg/m^3	u_{bs} < 2.5 µg/m^3				
Test of comparability					
All data					
Number of data		**196**	**195**	**196**	
Slope		**0,99**	**1,03**	**0,96**	
Intercept	Significant	**1,7**	**1,5**	**1,8**	
Calibrated data					
All data					
Number of data		**196**	**195**	**196**	
Calibration		**1,009y -1,681**	**0,975y -1,487**	**1,045y -1,865**	
Expanded relative uncertainty	25 %	**8,8 %**	**9,7 %**	**8,2 %**	**Pass**
Tasavallankatu: Tasa 1					
Number of data		**58**	**58**	**58**	
Calibration		**1,276y -3,881**	**1,268y -3,930**	**1,280y -3,806**	
Expanded relative uncertainty	25 %	**10,0 %**	**10,9 %**	**9,2 %**	**Pass**
Tasavallankatu: Tasa 2					
Number of data		**57**	**57**	**57**	
Calibration		**0,974y -2,365**	**0,926y -2,154**	**1,019y -2,519**	
Expanded relative uncertainty	25 %	**8,4 %**	**9,9 %**	**7,8 %**	**Pass**
Savilahdentie: Savi 1					
Number of data		**40**	**40**	**40**	
Calibration		**1,223y -2,986**	**1,243y -3,054**	**1,203y -2,911**	
Expanded relative uncertainty	25 %	**14,6 %**	**14,9 %**	**14,4 %**	**Pass**
Savilahdentie: Savi 2					
Number of data		**41**	**40**	**41**	
Calibration		**0,865y + 0,142**	**0,905y -0,042**	**0,913y -0,104**	
Expanded relative uncertainty	25 %	**20,8 %**	**21,0 %**	**19,7 %**	**Pass**

5.3.4 Summary of the $PM_{2.5}$ comparisons

The number of sites and the number of campaigns for the $PM_{2.5}$-comparison cover the requirements of the GDE. The meteorological conditions over the campaigns periods represent the annual variation met in Southern Finland. The concentration ranges at both sites in Kuopio were, however, quite low. Regarding to the suitability criterion, i.e. 20 % of the concentration of $PM_{2.5}$ during the whole measurement period should be higher than 17 µg/m^3, was not fulfilled. Figure 5.10 presents the monthly mean $PM_{2.5}$ concentrations from different parts in Finland together with the values obtained from this comparison. Considering the mass concentration of $PM_{2.5}$ in different locations in Finland, it is very unlikely to fulfill the suitability criterion in any part of Finland. At this $PM_{2.5}$ comparison tests, the suitability criterion was not considered as discarding factor for CMs.

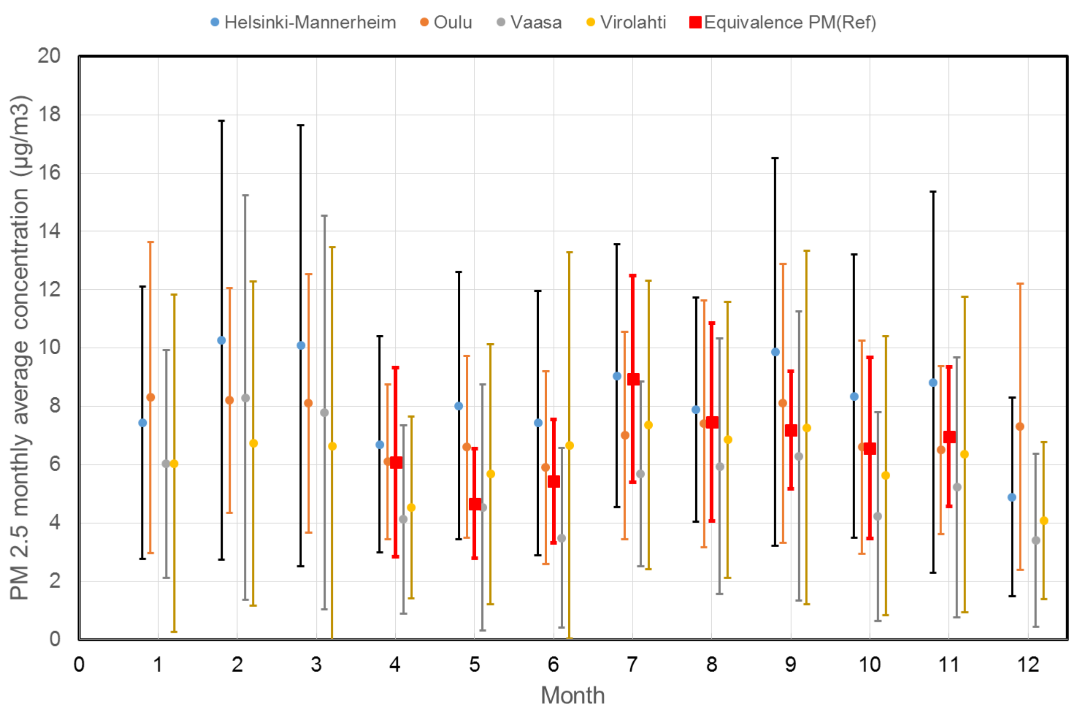

Figure 5.10: The monthly mean concentration of $PM_{2.5}$ in 2014-15 in Helsinki (blue dot), in Oulu (orange dot), in Vaasa (grey dot), a background station in Virolahti (brown dot), and in the $PM_{2.5}$ equivalence tests (red square).

Figure 5.10 shows that the concentration ranges from the comparison covers reasonably well the concentration ranges of $PM_{2.5}$ at different sites across Finland in spite of lack of data during the months in winter. The concentration range at the site of Helsinki-Mannerheim is however, higher compared with the concentrations in other stations.

Regarding the results for demonstration of equivalence, Tables 5.10 to 5.18, the data capture is fulfilled with the CMs. One of the BAM instrument had a technical problem which was not able to repair in due time causing a data capture of less than required. Suitability requirement for the concentration range measured during the comparison period, is not fulfilled by any of the CMs. The between test for CMs, is performed only to all data but not to data with the concentration above 18 µg/m^3 since there were no concentrations above this limit. The DustTrak failed the requirement for the between CM test. Test of comparability (see in Chapter 2.4 and 4.2) indicates that the correction of the data with the calibration equation needs to apply for all CMs except for β-signal of SHARP and slope of TEOM. Also with regard of the results of SHARP both of the signals are analyzed showing better performances for the β-signal than for the c-dust signal, which is the signal for normal use of the CM. The results of BAM failed with the number of measurements at one campaign, Savi 2, due to the jam of the filter roll. Due to the bad timing of the malfunction, the repair was not possible to organize as quickly as desirable.

5.4. Result of the field audit

The audit surveillance visit was conducted on June 4th, 2015 at the Savilandentie. The audit report is in Finnish, but the findings and the response is reported in Annex 28. Non-compliances were observed in some of the QA/QC procedures according to table 3.1, which were corrected or an influence could not be demonstrated in the results.

5.5. Calibration equations for CMs

The calibration equations from the comparability tests, tables 5.1 – 5.9, are collected for all data in the tables 5.19 and 5.20 for PM_{10} and for $PM_{2.5}$ candidate methods.

Table 5.19. The calibration range and the equations (see Eq. (2.2), b=slope, a=intercept and y = is the CM) against the reference method for PM_{10} together with the relative combined standard uncertainty.

PM10 Candidate method	< 325 µg/m3 Calibration equation PM_{10}	Relative expanded uncertainty	< 100 µg/m3 Calibration equation PM10	Relative expanded uncertainty	< 100 µg/m3 Calibration equation through origin PM10	Relative expanded uncertainty
BAM 1020	0,942y + 0,437	12,6%	0,858y + 1,919	10,3%	0,913y	11,7%
GRIMM 180	0,855y + 2,139	17,0 %	0,871y + 1,927	17,0 %	0,922y	17,9 %
SHARP 5030 C-dust	1,404y -2,750	17,2%	1,486y -3,904	16,5%	1,319y	16,3%
SHARP 5030 (beta)	1,415y -2,233	12,8%	1,489y -3,301	12,5%	1,351y	12,5%
FH 62 IR	1,300y -0,904	16,5%	1,372y -1,850	17,1%	1,297y	12,6%
TEOM 1405	0,868y -2,068	14,4%	0,804y -0,623	13,6%	0,788y	13,0%
MP101M	0,811y + 2,311	11,0%	0,887y + 0,826	9,4%	0,910y	9,6%
OSIRIS	1,401y -0,153	15,7%	1,338y + 0,57	15,3%	1,363y	15,7%
DustTrak	7,478y -76,819	402,3%	5,761y -55,073	1132,0%	2,07y	94,0%

Table 5.20: The calibration range and the equations (see Eq. (2.1), b=slope, a=intercept and y = the CM) against the reference method for $PM_{2.5}$ together with the relative combined standard uncertainty.

PM2.5 Candidate method	< 25 µg/m3 Calibration equation PM_{10}	Relative expanded uncertainty	< 25 µg/m3 Calibration equation through the origin PM2.5	Relative expanded uncertainty
BAM 1020	1,100y + 0,733	7,4%	1,215y	19,9%
GRIMM 180 (*	0,747y + 0,532	12,6 %	0,780y	12,3 %
SHARP 5030 C-dust	0,854y + 1,187	7,3%	1,009y	27,7%
SHARP 5030 (beta)	0,971y -0,003	0,2%	0,971y	0,2%
FH 62 IR	0,850y + 1,709	17,3%	1,097y	51,8%
TEOM 1405	1,009y -1,681	8,8%	0,821y	31,4%
MP101M	0,812y -0,306	8,9%	0,780y	31,4%
OSIRIS (*	3,324y -1,073	124,2%	2,020y	76,1%
Dusttrak (*	0,602y -1,002	37,9%	0,550y	143,9%
(* Range < 75 µg/m3				

The calibration equations in table 5.19 and table 5.20 are from the whole comparison data for both of the PM size classes. The concentration range met in PM_{10} comparison tests was from 0 to 325 µg/m^3, while the more practical concentration range in Finland is from 0 to 100 µg/m^3. In case of $PM_{2.5}$ the concentrations were relatively low and the estimated range for the applicability of the calibration equations in table 20 is from 0 to 25 µg/m^3 except for Grimm 180, Osiris and Dusttrak where the range is from 0 to 75 µg/m^3. At some of the CMs the calibration equation can be replaced with the slope (the right column at both of the tables). However, the calibration slope through the origin cannot be used with Dusttrak for PM_{10} measurements, or with SHARP (C-dust signal), FH 62 IR, TEOM 1405, MP101, Osiris and Dusttrak for $PM_{2.5}$ measurements.

The correction based on the tables 5.19 and 5.20, or by using the tables 5.1 to 5.18 is made according to:

$$y_{i,cal} = b \cdot y_i + a \tag{5.1}$$

Where

$y_{i,cal}$ = corrected values

b = slope of the calibration equation

y_i = measurement value (raw) of the CM

a = intercept of the calibration equation

The additional factors installed at the CM were removed when possible but in any case the factors if existing were the same for the same model of CM. The EU-factor in FH 62IR and SHARP were set to EU-factor = 1.00. The factory setting of this factor has been 1.3 by default. The TEOM 1405 corrects the signal by a correction factor of $TEOM = 1.03 \cdot y + 3\ \mu g/m^3$ where y is the raw signal of the TEOM. During the campaigns, the correction factor was not changed i.e. all results gained for TEOM includes the factory correction as default. At any other CMs there were no additional correction factors. The operator needs to be aware of the possible factors and their values in using the calibration equations to correct the results to be equivalent with the reference values.

5.4 Results of the automated PM analyzer at the Tasavallankatu

The final result of the comparison was to test the applicability of the gained calibration factor to the station analyzer, which was MP 101 for PM_{10}. The results of the comparability tests shows that the raw data needs to be corrected (see table 5.21 third column, MPM 101 raw). The correction is made according to table 5.19 calibration equation where the corrected results are presented in the 4th column at table 5.21. The corrected results give slightly overestimated results than the reference method with lower uncertainty than by using the raw data.

Table 5.21: The test results for the station analyzer, MP 101, at Tasavallankatu for PM_{10} measurement.

Test PM_{10}	**Criteria**	**MP101 raw**	**MP101 correct**	**Pass/Fail**
Data capture	≥ 90 % of RM	**98,0 %**	**98,0 %**	**Pass**
Suitability of data	20 % > 28 µg/m³	**Pass**	**Pass**	**Pass**
Test of comparability				
All data				
Number of data		**99**	**99**	
Slope	Significant	**1,08**	**0,95**	
Intercept	Significant	**-0,8**	**0,2**	
Calibrated data				
All data				
Number of data		**99**	**99**	
Calibration		**1,080y - 0,84**	**0,954y + 0,16**	
Expanded relative uncertainty	25 %	**17,7 %**	**13,7 %**	**Pass**
Tasavallankatu: Tasa 1				
Number of data		**48**	**48**	
Calibration		**1,1296y - 1,403**	**0,9969y - 0,30**	
Expanded relative uncertainty	25 %	**24,3 %**	**11,8 %**	**Pass**
Tasavallankatu: Tasa 2				
Number of data		**51**	**51**	
Calibration		**0,9889y + 0,046**	**0,874y + 0,92**	
Expanded relative uncertainty	25 %	**10,1 %**	**23,2 %**	**Pass**
> 30 µg/m³				
Number of data		**22**	**22**	
Calibration		**1,147y - 3,89**	**0,9264y - 0,89**	
Expanded relative uncertainty	25 %	**20,0 %**	**18,3 %**	**Pass**

6. Conclusions

The Air Quality Directive 2008/50/EC (AQD) defines the reference measurement methods for the atmospheric pollutants where limit or target values have been defined. Other measurement methods than the reference methods can be used for e.g. particulate matter if the Member State can demonstrate that the method displays a consistent relationship with the reference method. The comparison tests to study the equivalency between the automated PM analyzers and the reference method for measurements of mass concentration of $PM_{2.5}$ and PM_{10} were performed in accordance with the guidance document (GDE 2010). The automated PM analyzers of BAM 1020, DustTrak 8535, FH 62 I-R, Grimm model 180, MP101 CPM, Osiris, SHARP model 5030 and TEOM 1405 took part in the comparison to test the equivalency against the PM reference method both for the PM_{10} and $PM_{2.5}$ measurements in ambient air. The number of sites, campaigns, and the number of samples/campaign fulfilled the criteria of the GDE. The suitability criteria for the proportion to exceed the UAT values for more than 20 % were satisfied with the PM_{10} measurements, but not for $PM_{2.5}$ measurements. Consequently, the concentration range for applying the results for the CMs in $PM_{2.5}$ measurements was defined.

Care shall be taken when comparing the results of this study with others in case of the environmental conditions, but also with the concentration levels, origin and composition of particles. The composition of particles can be formed from a fraction of semi volatile compounds that can be quite different from various parts in Finland but more likely different across the Europe. The fraction of semi-volatile compounds was not measured and not taken into account in the calibration equations due to the lack of proper instrumentation. Estimation of the semi-volatile compounds have been performed in Finland by different techniques (Timonen et al. 2012, Ruoho-Airola 2014) indicating proportion of semi-volatile compounds between 10 to 18 % of concentration in $PM_{2.5}$. At Tasavallankatu in Kuopio the source area of $PM_{2.5}$ is evenly distributed into the wind sectors showing the various sources of particles while in Savilahdentie the source area is clearly from the traffic side. In case of PM_{10} the source area is even more concentrated on the traffic side at both sites. The content of the particles from the traffic side are mainly silica-based particles and combustion based particles. Considering that the source area, especially for PM_{10} was more concentrated in the sector where solid particles gives the major contribution on mass, this may have more influence on the optical methods than in β attenuation or micro balance method. This can be the origin for the variation of the calibration factors from different campaigns, especially with optical methods. Also the calibration equations differs more for the winter campaign, indicating some problems in sampling due to the collection of snow on the sampling inlets. The configuration, software (versions of firmware), materials and equipment can vary in the CMs, raising a question whether the results are applicable to be used elsewhere. There were no modifications on the operation of the CMs except the sampling time for BAM 1020, which was 3 hour instead of 1 hour. The maintenance of the CMs were performed according to the manual and by Finnish representatives of the manufacturer. The QA/QC procedures were performed according to the GDE and the manufacturer instructions.

The results showed that only one CM of the tested analyzers, DustTrak 8535, failed to meet the criteria for equivalence for fixed measurements of $PM_{2.5}$ and PM_{10}. Osiris fulfilled the criteria for PM_{10} measurements, but failed to meet the criteria for $PM_{2.5}$ measurements. All the other CMs, FH 62 I-R, Grimm model 180, MP101 CPM, SHARP model 5030, TEOM 1405 and BAM 1020 fulfilled the criteria for the reference method for $PM_{2.5}$ and for PM_{10} measurements in ambient air. The calibration equations calculated for the CMs can be used for correcting the measured concentration values. It is, however, the task of the responsible authority in the member state to approve the tested CMs with the calibration equation as an equivalent method to be used for the measurement of mass concentration of $PM_{2.5}$ and PM_{10} in ambient air according to the air quality directive.

Acknowledgements

The project was funded by the Ministry of Environment, Ministry of Traffic and Communication and the Finnish Meteorological Institute. The authors like to express their special thanks to Mr Erkki Pärjälä and Mikko Sokura from the City of Kuopio for excellent cooperation and help during the whole course of the comparison experiments. The Manufacturers, Finnish representatives, JPP-kalibrointi KY, Estonian Environmental Research Centre, the Expert Service Group and the Observation Group at the Finnish Meteorological Institute are thanked for their help and providing the candidate methods for testing. Ministerial Adviser, Tarja Lahtinen from the Ministry of Environment is thanked for keen interest and valuable comments during the project and Dr Virpi Tarvainen for revising the language.

7. References

Beijk R, Hoogerbrugge R, Hafkenscheid TL, Arkel FT van, Stefess GC, Meulen A van der, Wesseling JP, Sauter FJ, Albers RAW, RIVM rapport 680708001, (www.rivm.nl)

Bertrand, L., Gérard G., and Schroyen G., (2009). PM_{10} and $PM_{2,5}$ Equivalence test Lodelinsart, Progress report (winter 2008-2009) Rapport no 09-960, Institut scientifique de service public, (http://airquality.issep.be).

De Jonge D. (2008). Field experiment on 11 automated PM monitors. Technical report. Department of Air Quality Research, Municipal Health Service Amsterdam, (GGD Amsterdam).

AQD 2008/50/EC: Directive of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe

EC WG on PM (2001). Report on guidance to member states on PM_{10} monitoring and intercomparisons with the reference method.

Matos, J. et al. 2008. Determinação do factor equivalência entre método referência e automático PM10 Estação de Referência do Ambiente Alfragide 2008 Amadora 2008 (http://www.apambiente.pt/servicos/LaboratorioReferencia/EstacaoReferenciaQualidade Ar/Documents/Factor equivalencia metodo referencia e automatico PM10 APA 2008.pdf)

EN12341 Air Quality – Determination of the PM10 fraction of suspended particulate matter – reference method and field test procedure to demonstrate reference equivalence of measurement methods. November 1998.

EN12341: 2014. Air Quality – Standard gravimetric measurement method for the determination of the PM_{10} or $PM_{2.5}$ mass concentration of suspended particulate matter.

EN14907 Ambient air quality Standard gravimetric measurement method for the determination of the PM2.5 mass fraction of suspended particulate matter. September 2005.

EN 15267-1 Air quality. Certification of automated measuring systems. Part 1: General principles

EN 15267-2 Air quality. Certification of automated measuring systems. Part 2: Initial assessment of the AMS manufacturer's quality management system and post certification surveillance for the manufacturing process.

EnviDas for Windows, 2003. Environmental Data Acquisition System, Envitech Ltd.

Enview 2000 Software manager 2004. Environmental data Management Systems, Envitech Ltd.

Demonstration of Equivalence of Ambient Air Monitoring Methods; 2005, EC-working group on guidance for the demonstration on equivalence) (http://ec.europa.eu/environment/air/pdf/equivalence_report.pdf)

Harrison et al. (2006). UK Equivalence Programme for Monitoring of Particulate Matter, Final report BV/AQ/AD202209/DH/2396, June 5, 2006.

Järvi, L., Hannuniemi, H., Hussein, T., Junninen, H., Aalto, P., Hillamo, R., Mäkelä, T., Keronen, P., Siivola, E., Vesala, T. and Kulmala, M.: The urban measurement station SMEAR III: Continuous monitoring of air pollution and surface-atmosphere interactions in Helsinki, Finland. Boreal. Environ. Research., 14 suppl. A, 86-109, 2009

Kaminski H. and Kuhlbusch T., 2010. Überprüfung der Trenngrade zweier PM_{10} – Vorabscheider für 2,3 m3/h mittels Messung mit polydispersem Aerosol. Bericht Nr LP. 59/2010. Institute für Energie- und Umwelttechnik e. V. (IUTA).

LUBW 2 21-18, 2005. Prüfung des schwestaubmessgerätes environmental dust monitor – Model 180 der firma Grimm Aerosoltechnik auf Gleichwertige ergebnisse wie mit der referenzmethode der Europäischen norm Din EN 12341 bei der messung von schwebstaub der fraktion PM_{10}.

Pirinen, P., Simola, H., Aalto, J., Kaukoranta, J-P., Karlsson, P., Ruuhela, R., 2012. Tilastoja Suomen ilmastosta 1981–2010. 83 s.

Walden, J., Hillamo, R., Aurela, M., Makela, T., Laurila, S., 2010. Demonstration of the equivalence of $PM_{2.5}$ and PM_{10} measurement methods in Helsinki 2007-2008. 103 s. Finnish Meteorological Institute, Studies 3, Helsinki.

WHO (2006) *Health risk of particulate matter from long-range transboundary air pollution.* Joint WHO/Convention Task Force on the health aspects of air pollution. Denmark: World Health Organization Europe, Publication E88189.

Annexes

A1: QA/QC procedures conducted for the RM and CM during the comparison experiments.

Table A1a. The flow rates of the RMs and CMs equipped with the size selective inlets. Measurements are expressed as [l/min] at prevailing ambient air conditions.

Date	Leckel RM1	Leckel RM2	Sharp A	Sharp B	TEOM B	TEOM A	MP-101 A	MP-101 B	FH62 B	FH62 A	BAM A	BAM B
16.4.2014	38,3	38,2		19,3	17,4	18,1	15,3	17,5	18,1	18,4	18,1	17,9
24.6.2014	39,2	39,9		18,4	17,2	17,3	14,9	16,9	17,4	17,5	17,2	17,1
9.7.2014												
15.7.2014	37,9	38,1		17,1	16,9	16,5			16,1	16,4	16,2	16,1
29.7.2014	38,0	37,6	15,9	16,7	16,8	16,4	16,7	15,8	16,0	15,7	15,8	16,0
9.9.2014			16,3	17,4	16,9	16,9	17,1	16,3	16,5	16,8	16,8	16,8
7.10.2014	38,5	38,5	16,5	16,5	15,6	16,8	16,6	16,3	16,4	16,5	16,5	16,4
9.1.2015			16,0	16,0	16,1	16,3	16,1	15,6	16,2	16,1	16,0	16,2
18.2.2015	38,5	38,2	16,4	16,3	17,0	16,4	16,4	16,4	16,4	16,6	16,5	16,6
5.3.2015	38,5	38,3										
1.4.2015	37,5	37,6	16,1	16,0	16,6	16,4	16,2	16,4	16,2	16,4	16,2	16,2
9.4.2015	38,2	38,2	16,7	16,3	17,0	16,7	16,5	15,3	16,6	16,6	16,6	16,6
6.5.2015	38,5	38,6	16,5	16,5	17,3	17,4	16,8	17,0	16,9	16,9	16,8	16,8
1.7.2015	39,3	39,2	16,6	16,6	17,7	17,7	17,0	16,7	16,9	17,0	16,9	17,0

Table A1.b. Ambient pressure (hPa) measurements during the check of flow rates of each RMs and CMs.

Date	Leckel Nr 1	Leckel Nr 2	Sharp A	Sharp B	TEOM B	TEOM A	MP-101 A	MP-101 B	FH62 B	FH62 A	BAM2 A	BAM1 B
16.4.2014			98,5	99,8	99,8	99,8	99,8	99,8	99,8	99,8	99,8	99,8
24.6.2014	98,9	98,9	98,9	98,9	98,9	98,9	98,9	98,9	98,9	98,9	98,9	98,9
9.7.2014	99,8	99,8										
15.7.2014	99,3	99,3	99,2	99,2	99,2	99,2			99,2	99,2	99,3	99,3
29.7.2014	98,7	98,7	98,7	98,7	98,7	98,7	98,7	98,7	98,7	98,7	98,7	98,7
9.9.2014			99,4	99,4	99,4	99,4	99,4	99,4	99,3	99,3	99,3	99,3
7.10.2014	99,1	99,1	99,1	99,1	99,1	99,1	99,1	99,1	99,1	99,2	99,1	99,1
9.1.2015			96,6	96,6	96,6	96,6	96,6	96,6	96,6	96,6	96,6	96,6
18.2.2015	98,7	98,7	98,7	98,7	98,7	98,7	98,7	98,7	98,7	98,7	98,7	98,7
5.3.2015	100,1	100,1										
1.4.2015	97,6	97,6	97,5	97,5	97,5	97,5	97,5	97,5	97,5	97,5	97,4	97,5
9.4.2015	99	99	99	99	99	99	99	99	99	99	99	99
6.5.2015	99,3	99,3	99,3	99,3	99,3	99,3	99,3	99,3	99,3	99,3	99,3	99,3
1.7.2015	100,5	100,5	100,5	100,5	100,5	100,5	100,5	100,5	100,5	100,5	100,5	100,5

Table A1.c. Ambient temperature (°C) measurements during the check of flow rates of each RMs and CMs.

Date	Leckel Nr 1	Leckel Nr 2	Sharp A	Sharp B	TEOM B	TEOM A	MP-101 A	MP-101 B	FH62 B	FH62 A	BAM2 A	BAM1 B
16.4.2014			7,5	7,5	7,5	7,5	7,5	7,5	7,5	7,4	7,2	7,4
24.6.2014	14	14	14	14	14	14	14	14	14	14	14	14
9.7.2014	27,6	27,6										
15.7.2014	27	27	24,2	24,1	23,8	24,5			24,1	24,1	27,4	27,4
29.7.2014	24	24	24	24	24	24	24	24	30	30	30	25
9.9.2014			21	21	21	21	21	21	20,5	20,5	20,5	20,5
7.10.2014	-2,7	-2,7	-2	-2	-2	-2	-2	-2	-2	-1	-2	-2
9.1.2015			0,4	-0,2	0	-0,3	-0,4	-0,4	0,2	0	0,4	0,2
18.2.2015	0,6	0,8	0,8	1,2	0,6	0,9	0,9	0,9	1,2	1,7	1,3	0,5
5.3.2015	2	2										
1.4.2015	1,1	1,2	1,7	1,7	1,6	1,6	1,6	1,7	1,7	1,6	2,2	2,2
9.4.2015	4,4	4,4	5,7	5,3	5,3	5,5	5,1	5,7	5,3	5,3	5,8	5,8
6.5.2015	15,6	15,6	16	16	15,6	15,6	16	15,6	16	16	16,6	16,3
1.7.2015	19,9	19,9	19,9	19,9	19,9	19,9	19,9	19,9	19,9	19,9	19,9	19,9

Table A1.d. Cleaning and greasing of the inlets of the RMs and CMs.

Leckel (11/0070)	Leckel (09/0081)	SHARP A / B	TEOM A / B	MP-101 A / B	FH-62-IR A / B	BAM A / B	Dust track	Grimm
2.4.2014	3.4.2014	29.4.2014	29.4.2014	29.4.2014	29.4.2014	29.4.2014	9.4.2015	1.7.2014
29.4.2014	30.4.2014	10.6.2014	10.6.2014	10.6.2014	10.6.2014	10.6.2014		9.4.2015
27.5.2014	27.5.2014	16.7.2014	16.7.2014	16.7.2014	16.7.2014	16.7.2014		
24.6.2014	25.6.2014	7.10.2014	7.10.2014	7.10.2014	7.10.2014	7.10.2014		
16.7.2014	16.7.2014	5.12.2014	5.12.2014	5.12.2014	5.12.2014	5.12.2014		
12.8.2014	13.8.2014	21.1.2015	21.1.2015	21.1.2015	21.1.2015	21.1.2015		
9.9.2014	9.9.2014	18.3.2015	18.3.2015	18.3.2015	18.3.2015	18.3.2015		
21.10.2014	22.10.2014	9.4.2015	9.4.2015	9.4.2015	9.4.2015	9.4.2015		
18.11.2014	19.11.2014	6.5.2015	6.5.2015	6.5.2015	6.5.2015	6.5.2015		
5.12.2014	5.12.2014	3.6.2015	3.6.2015	3.6.2015	3.6.2015	3.6.2015		
8.1.2015	8.1.2015	1.7.2015	1.7.2015	1.7.2015	1.7.2015	1.7.2015		
4.2.2015	5.2.2015							
18.2.2015	19.2.2015							
18.3.2015	19.3.2015							
9.4.2015	9.4.2015							
22.4.2015	22.4.2015							
20.5.2015	20.5.2015							
3.6.2015	3.6.2015							
15.6.2015	15.6.2015							
1.7.2015	1.7.2015							

Table A1. e. Software versions of the instruments

INSTRUMENTS	Serial number	SOFTWARE version	Changes during the	Changes on the performanc	Date	Additional factors installed on signal
Leckel SEQ 47/50			No	No		No
Leckel SEQ 47/50			No	No		No
Environnement MP-101+CPM A	3298	v 3.6 e	No	No		No
Environnement MP-101+CPM B	3008	v 3.6 i	No	No		No
GRIMM-180 B	18A07019	Firmware Version,12.30	No	No		No
GRIMM-180 C	18A06016	Firmware Version, 12.30	No	No		No
SHARP 5030 A	E-204	Firmware version V1.16	V1.21	No changes on the performance of the instrument	During maintenance of the instrument. Performed by the Finnish representative 15.7.2014	No
SHARP 5030 B	E-2154	Firmware version V1.16	V1.21	No changes on the performance of the instrument	During maintenance of the instrument. Performed by the Finnish representative 15.7.2014	No
FH-62-IR A	1163	V 1.10	No	No		No
FH-62-IR B	1159	V 1.10	No	No		No
BAM 1020 A	H1207	3236-02 3.1.0	No	No		No
BAM 1020 B	H1208	3236-02 3.1.0	No	No		No
TEOM-1405 A	1405A2 2686 1312	Version 1.57.00	No	No		1.03*Sign + 3
TEOM-1405 B	1405A2 2638 1310	Version 1.57.00	No	No		1.03*Sign + 3
OSIRIS A	TNO 3384	Rev. 04.34	No	No		No
OSIRIS B	TNO 3383	Rev. 04.34	No	No		No
DUST TRAK DRX 8533 EP A	8533144308	Firmware Version,3.3	No	No		No
DUST TRAK DRX 8533 EP B	8533144421	Firmware Version,3.3	No	No		No

A2 PM_{10} equivalence tests for BAM

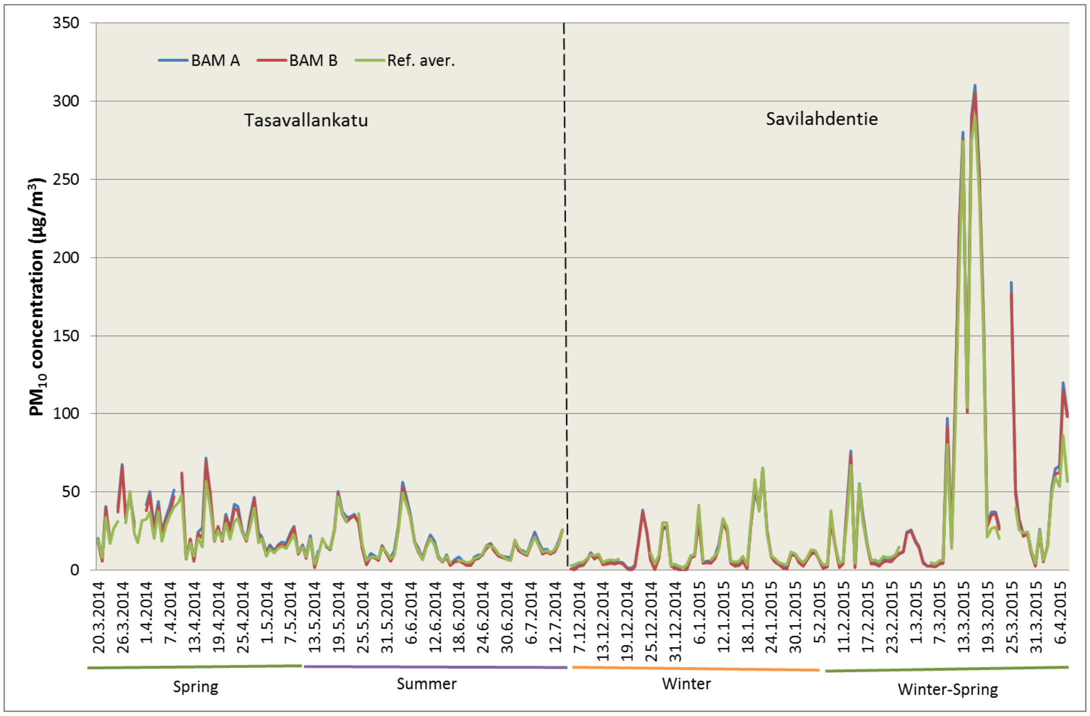

Figure A2.1. Time series of 24 h concentration values of BAM and the RMs during the PM_{10} equivalence campaigns in Kuopio.

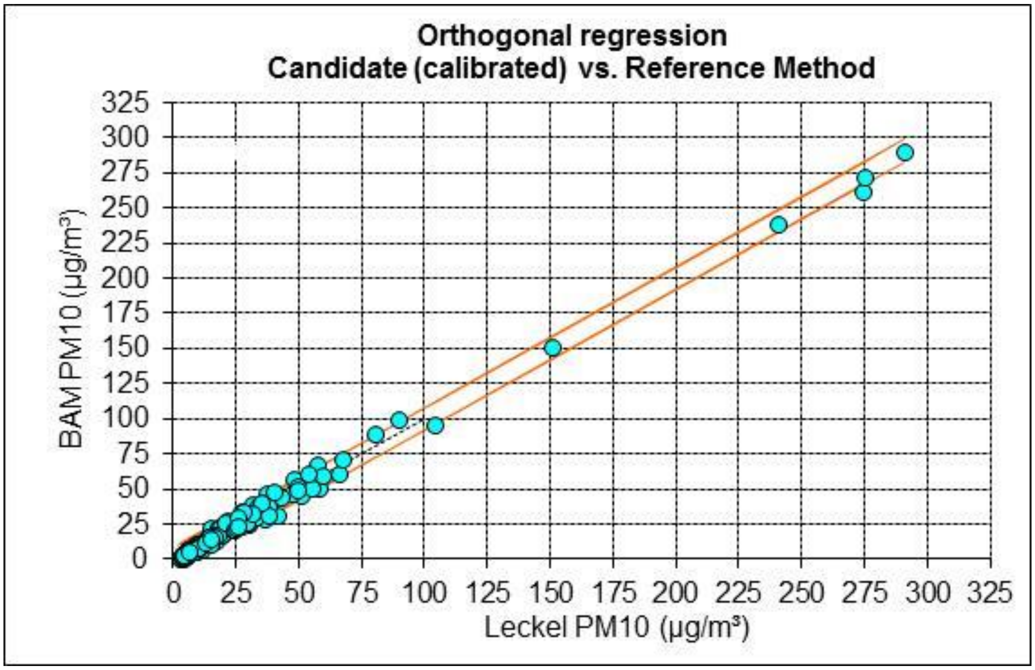

Figure A2.2: Scatter plot of BAM impactor versus the RMs: Calibrated data.
Table A2.1. Equivalence test results for BAM against the RMs for PM10, all data

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**0,942y + 0,437**		N (Spring)	93	n
Regression (i=0)	**0,947y**		N (Summer)	43	n
N	211	n	N (Fall)	0	n
			N (Winter)	75	n
Outliers	13	n	Outliers	10	n
Outliers	6,2%	%	Outliers	4,7%	%
Mean CM	25,1	µg/m³	Mean CM	24,071	µg/m³
Mean RM	24,1	µg/m³	Mean RM	24,071	µg/m³
Number of RM > 0,6 * LV	46	n	Number of CM > 0,6 * LV	49	n
Number of RM > LV	16	n	Number of CM > LV	17	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**1,06178**	**significant**	**Slope b**	1,000	
Uncertainty of b	0,006		Uncertainty of b	0,006	
Intercept a	**-0,46385**		**Intercept a**	0,005	
Uncertainty of a	0,281		Uncertainty of a	0,264	
r^2	0,993		r^2	0,993	
Slope b forced trough origin	**1,056**	**significant**			
Uncertainty of b (forced)	0,0052				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,42	µg/m³	**Calibration**	**0,942y + 0,437**	
Uncertainty of calibration (forced)	0,26	µg/m³	**u(calibration)**	**0,415**	µg/m³
Random term	3,33	µg/m³	Random term	3,14	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	2,63	µg/m³	Bias at LV	-0,01	µg/m³
Combined uncertainty	4,24	µg/m³	Combined uncertainty	3,14	µg/m³
Expanded relative uncertainty	**16,9%**	***pass***	**Expanded relative uncertainty**	**12,6%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	50	µg/m³	Limit value	50	µg/m³

A3. PM_{10} equivalence tests for DustTrak analyzers

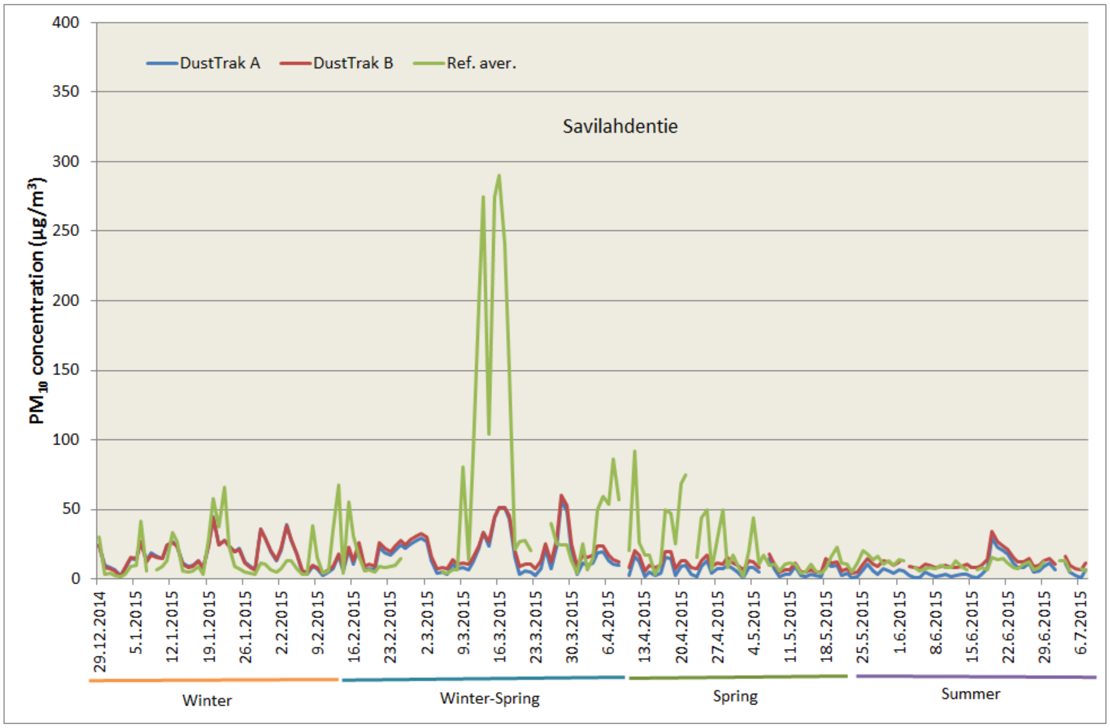

Figure A3.1: Time series of 24 h concentration values of DustTrak and the RMs during the PM_{10} equivalence campaigns in Kuopio.

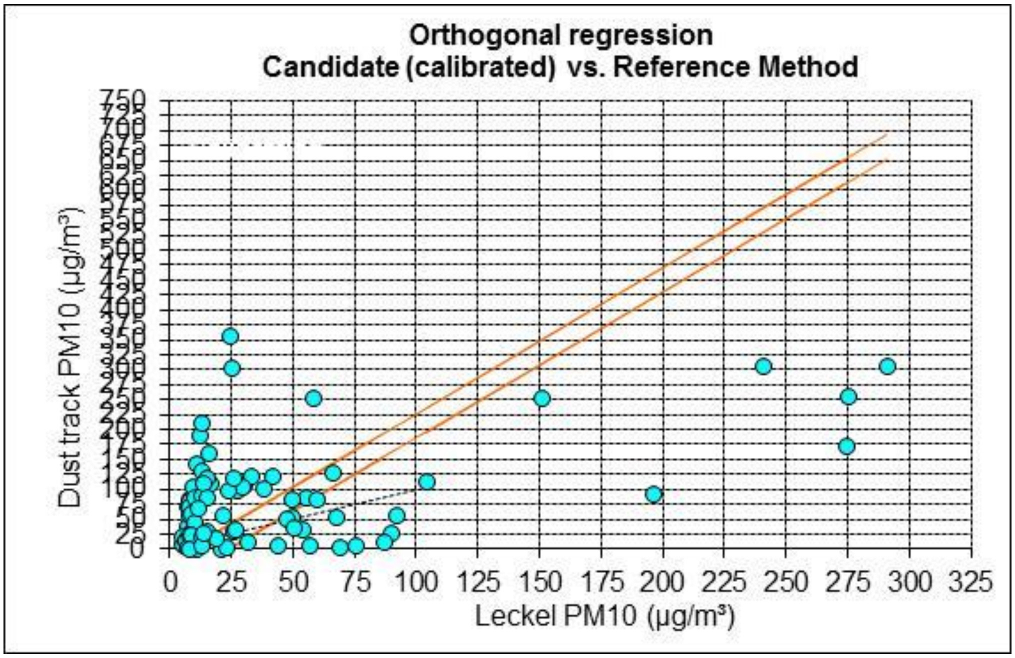

Figure A3.2. Scatter plot of DustTrak versus the RMs: Calibrated data.

Table A3.1. Equivalence test results for DustTrak against the RMs for PM_{10}, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**7,478y + -76,819**		N (Spring)	82	n
Regression (i=0)	**4,16y**		N (Summer)	31	n
N	171	n	N (Fall)	0	n
			N (Winter)	58	n
Outliers	5	n	Outliers	112	n
Outliers	2,9%	%	Outliers	65,5%	%
Mean CM	13,8	µg/m³	Mean CM	26,571	µg/m³
Mean RM	26,6	µg/m³	Mean RM	26,571	µg/m³
Number of RM > 0,6 * LV	35	n	Number of CM > 0,6 * LV	57	n
Number of RM > LV	21	n	Number of CM > LV	48	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**0,13373**	significant	**Slope b**	2,446	significant
Uncertainty of b	0,015		Uncertainty of b	0,110	
Intercept a	**10,27330**	significant	**Intercept a**	-38,413	significant
Uncertainty of a	0,777		Uncertainty of a	5,807	
r^2	0,314		r^2	0,314	
Slope b forced trough origin	**0,240**	significant			
Uncertainty of b (forced)	0,0182				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	1,07	µg/m³	**Calibration**	**7,478y -76,819**	
Uncertainty of calibration (forced)	0,91	µg/m³	**u(calibration)**	**1,068**	µg/m³
Random term	8,73	µg/m³	Random term	94,70	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	-33,04	µg/m³	Bias at LV	33,87	µg/m³
Combined uncertainty	34,17	µg/m³	Combined uncertainty	100,57	µg/m³
Expanded relative uncertainty	**136,7%**	**fail**	**Expanded relative uncertainty**	**402,3%**	**fail**
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	50	µg/m³	Limit value	50	µg/m³

A4. PM_{10} equivalence tests for FH 62 I-R analyzers

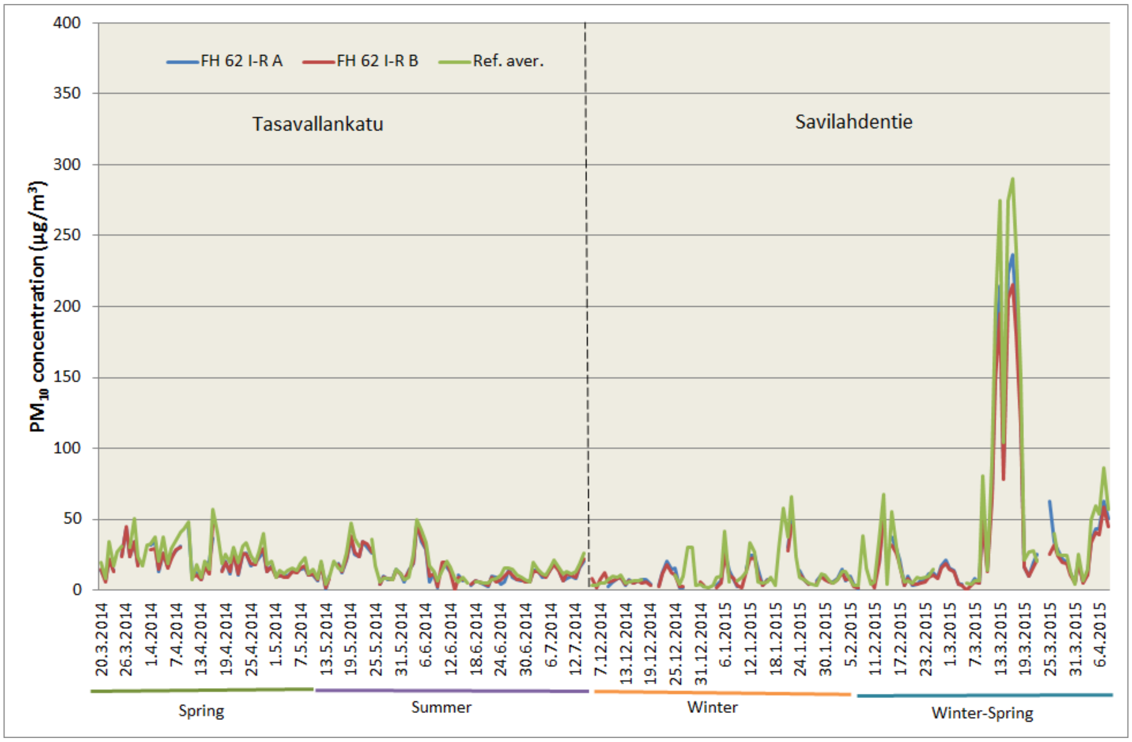

Figure A4.1: Time series of 24 h concentration values of FH 62 I-R and the RMs during the PM_{10} equivalence campaigns in Kuopio.

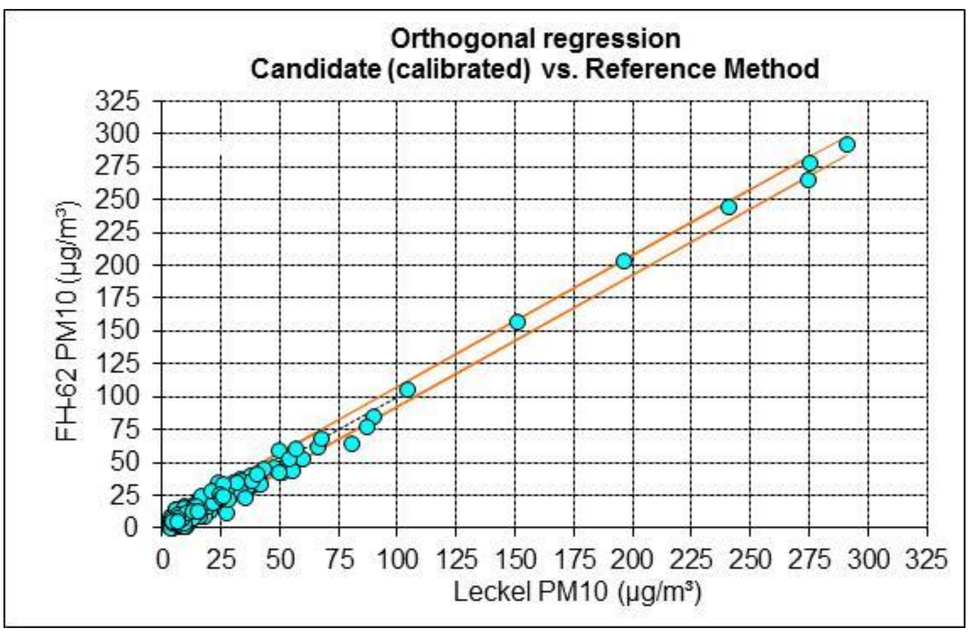

Figure A4.2. Scatter plot of FH 62 I-R versus the RMs: Calibrated data

Table A4.1. Equivalence test results for FH 62 I-R against the RMs for PM_{10}, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**1,3y + -0,904**		N (Spring)	92	n
Regression (i=0)	**1,288y**		N (Summer)	40	n
N	195	n	N (Fall)	0	n
			N (Winter)	63	n
Outliers	7	n	Outliers	20	n
Outliers	3,6%	%	Outliers	10,3%	%
Mean CM	20,7	µg/m³	Mean CM	26,068	µg/m³
Mean RM	26,1	µg/m³	Mean RM	26,068	µg/m³
Number of RM > 0,6 * LV	44	n	Number of CM > 0,6 * LV	42	n
Number of RM > LV	18	n	Number of CM > LV	17	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**0,76908**	**significant**	**Slope b**	1,001	
Uncertainty of b	0,006		Uncertainty of b	0,007	
Intercept a	**0,69496**	**significant**	**Intercept a**	-0,033	
Uncertainty of a	0,274		Uncertainty of a	0,356	
r^2	0,990		r^2	0,990	
Slope b forced trough origin	**0,777**	**significant**			
Uncertainty of b (forced)	0,0048				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,39	µg/m³	**Calibration**	**1,300y -0,904**	
Uncertainty of calibration (forced)	0,24	µg/m³	**u(calibration)**	**0,388**	µg/m³
Random term	3,10	µg/m³	Random term	4,13	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	-10,85	µg/m³	Bias at LV	0,03	µg/m³
Combined uncertainty	11,28	µg/m³	Combined uncertainty	4,13	µg/m³
Expanded relative uncertainty	**45,1%**	**fail**	**Expanded relative uncertainty**	**16,5%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	50	µg/m³	Limit value	50	µg/m³

A5. PM_{10} equivalence tests for Grimm analyzers

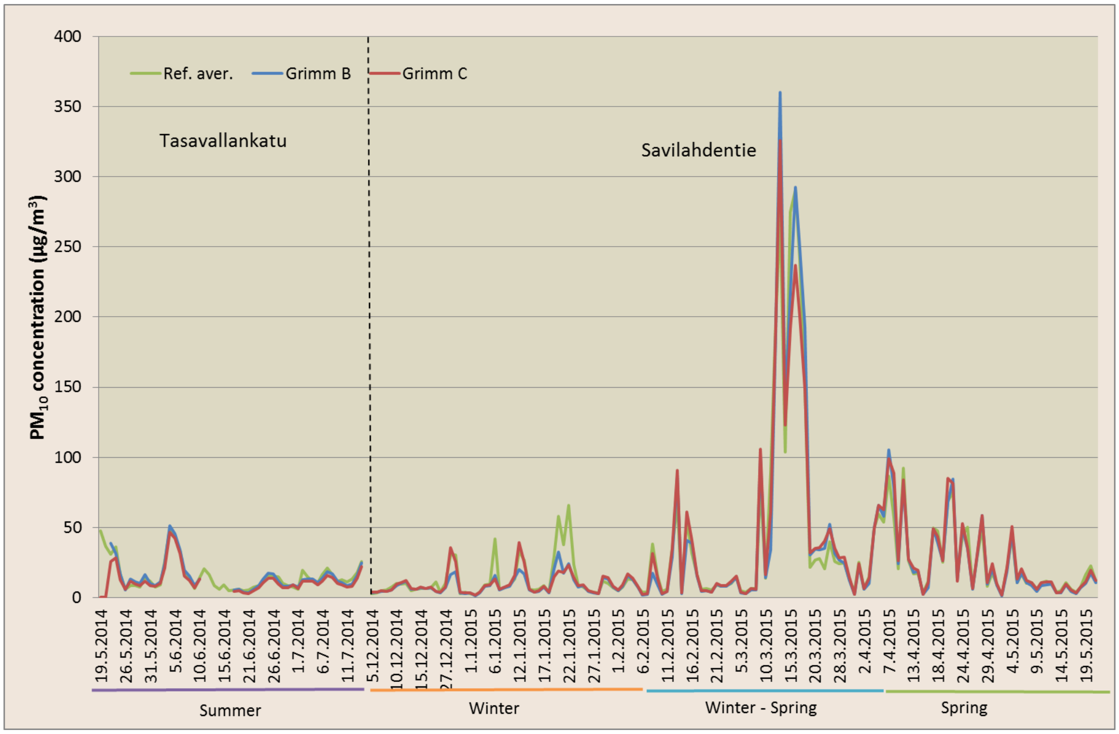

Figure A5.1: Time series of 24 h concentration values of Grimm and the RMs during the PM_{10} equivalence campaigns in Kuopio.

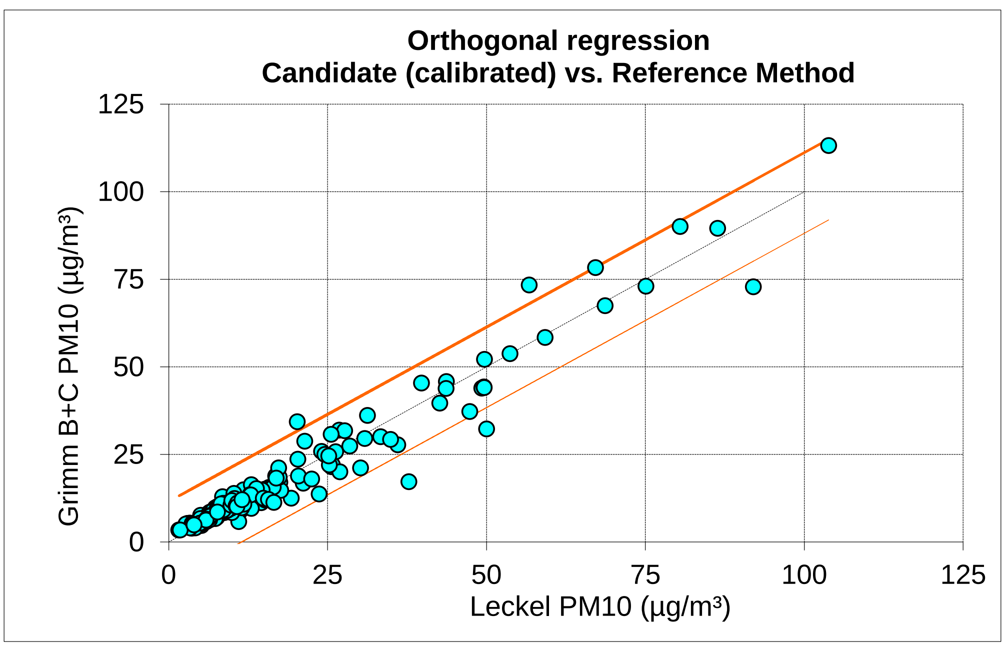

Figure A5.2. Scatter plot of Grimm versus the RMs: Calibrated data

Table A5.1. Equivalence test results for Grimm against the RMs for PM_{10}, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**0,855y + 2,139**		N (Spring)	45	n
Regression (i=0)	**0,908y**		N (Summer)	53	n
N	179	n	N (Fall)	14	n
			N (Winter)	67	n
Outliers	8	n	Outliers	5	n
Outliers	4,5%	%	Outliers	2,8%	%
Mean CM	17,7	µg/m^3	Mean CM	17,312	µg/m^3
Mean RM	17,3	µg/m^3	Mean RM	17,312	µg/m^3
Number of RM > 0,6 * LV	27	n	Number of CM > 0,6 * LV	26	n
Number of RM > LV	11	n	Number of CM > LV	11	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**1,16941**	significant	**Slope b**	0,996	
Uncertainty of b	0,020		Uncertainty of b	0,017	
Intercept a	**-2,50173**	significant	**Intercept a**	0,075	
Uncertainty of a	0,508		Uncertainty of a	0,435	
r^2	0,946		r^2	0,946	
Slope b forced trough origin	**1,102**	significant			
Uncertainty of b (forced)	0,0152				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	1,14	µg/m^3	**Calibration**	**0,855y + 2,139**	
Uncertainty of calibration (forced)	0,76	µg/m^3	**u(calibration)**	**1,136**	µg/m^3
Random term	4,85	µg/m^3	Random term	4,26	µg/m^3
Additional uncertainty (optional)	0,00	µg/m^3	Additional uncertainty (optional)	0,00	µg/m^3
Bias at LV	5,97	µg/m^3	Bias at LV	-0,14	µg/m^3
Combined uncertainty	7,69	µg/m^3	Combined uncertainty	4,26	µg/m^3
Expanded relative uncertainty	**30,8%**	**fail**	**Expanded relative uncertainty**	**17,0%**	***pass***
Ref sampler uncertainty	1,00	µg/m^3	Ref sampler uncertainty	1,00	µg/m^3
Limit value	50	µg/m^3	Limit value	50	µg/m^3

A6. PM10 equivalence tests for Environnement MP101 analyzers

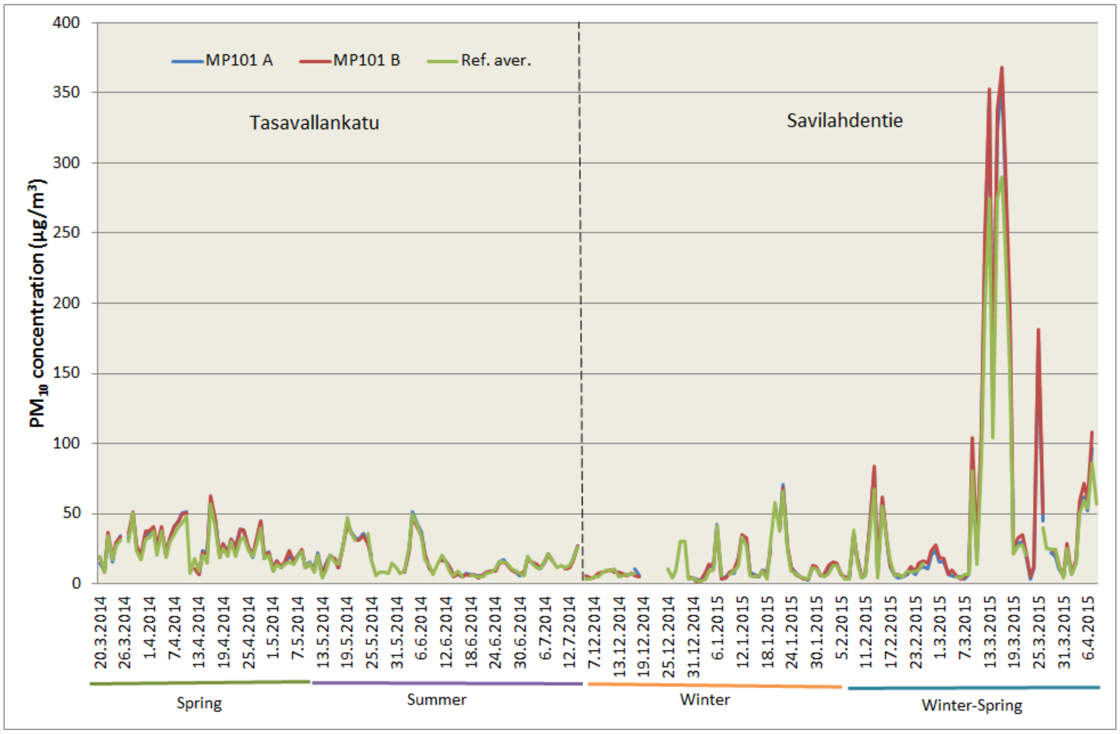

Figure A6.1: Time series of 24 h concentration values of MP101 and the RMs during the PM_{10} equivalence campaigns in Kuopio

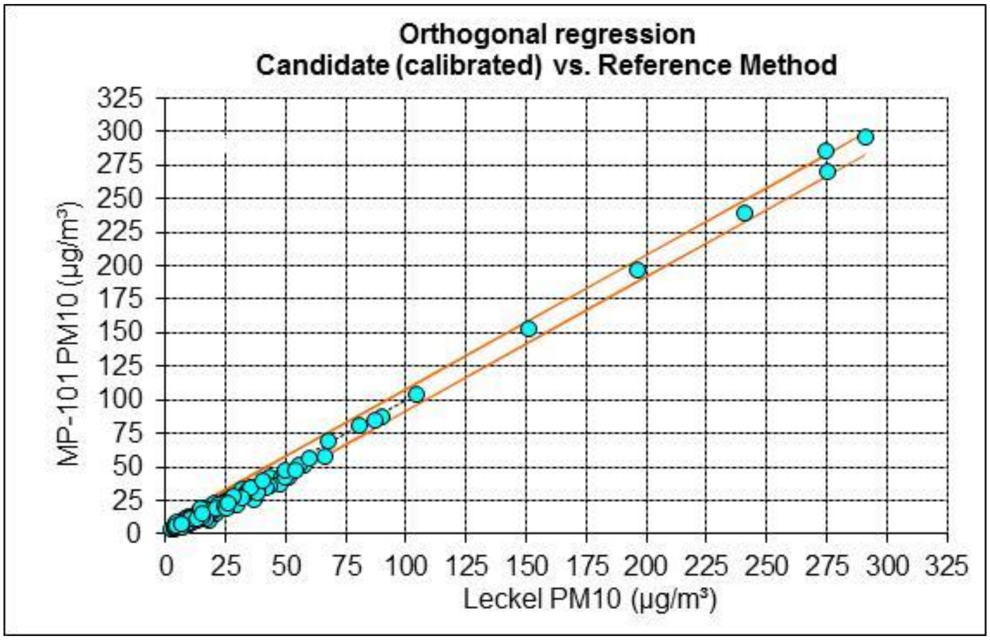

Figure A6.2: Scatter plot of MP101 versus the RMs: Calibrated data.

Table A6.1. Equivalence test results for MP101 against the RMs for PM_{10}, all data

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**0,811y + 2,311**		N (Spring)	70	n
Regression (i=0)	**0,83y**		N (Summer)	50	n
N	201	n	N (Fall)	12	n
			N (Winter)	69	n
Outliers	8	n	Outliers	3	n
Outliers	4,0%	%	Outliers	1,5%	%
Mean CM	29,3	µg/m³	Mean CM	26,090	µg/m³
Mean RM	26,1	µg/m³	Mean RM	26,090	µg/m³
Number of RM > 0,6 * LV	47	n	Number of CM > 0,6 * LV	44	n
Number of RM > LV	17	n	Number of CM > LV	15	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**1,23377**	significant	**Slope b**	1,000	
Uncertainty of b	0,006		Uncertainty of b	0,005	
Intercept a	**-2,85155**	significant	**Intercept a**	0,013	
Uncertainty of a	0,296		Uncertainty of a	0,240	
r^2	0,995		r^2	0,995	
Slope b forced trough origin	**1,204**	significant			
Uncertainty of b (forced)	0,0061				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,42	µg/m³	**Calibration**	**0,811y + 2,311**	
Uncertainty of calibration (forced)	0,30	µg/m³	**u(calibration)**	**0,422**	µg/m³
Random term	3,42	µg/m³	Random term	2,74	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	8,84	µg/m³	Bias at LV	-0,01	µg/m³
Combined uncertainty	9,47	µg/m³	Combined uncertainty	2,74	µg/m³
Expanded relative uncertainty	**37,9%**	**fail**	**Expanded relative uncertainty**	**11,0%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	50	µg/m³	Limit value	50	µg/m³

A7. PM_{10} equivalence tests for Osiris analyzers

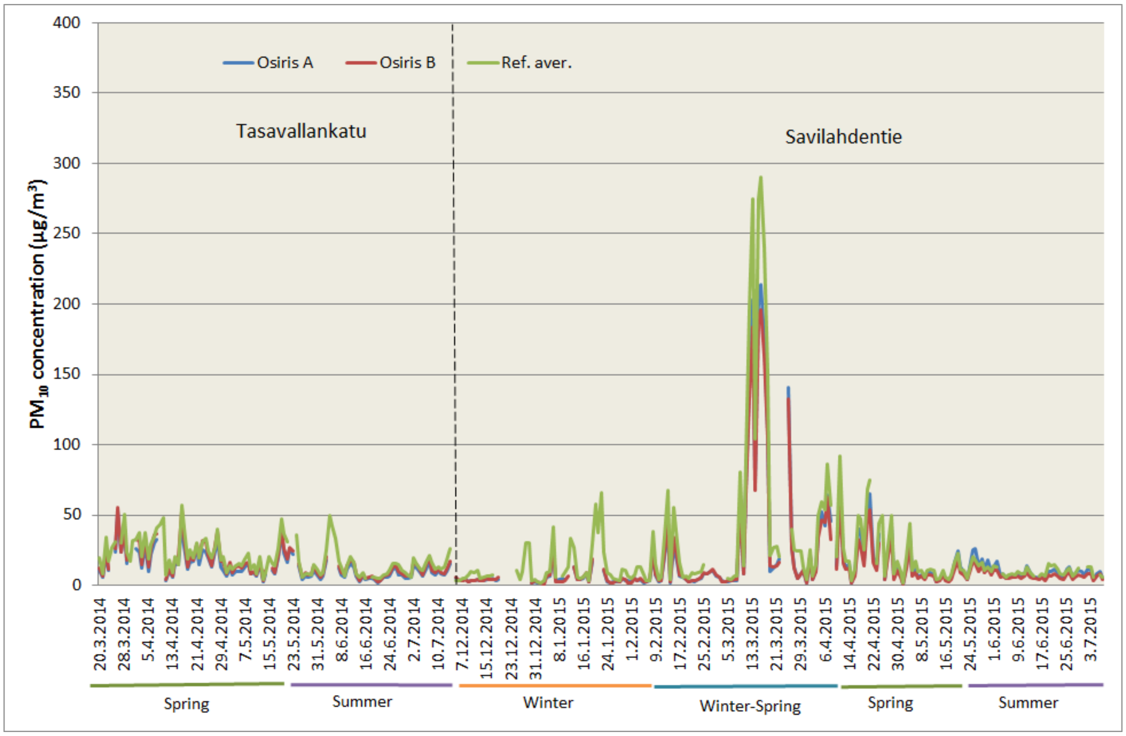

Figure A7.1: Time series of 24 h concentration values of Osiris and the RMs during the PM_{10} equivalence campaigns in Kuopio.

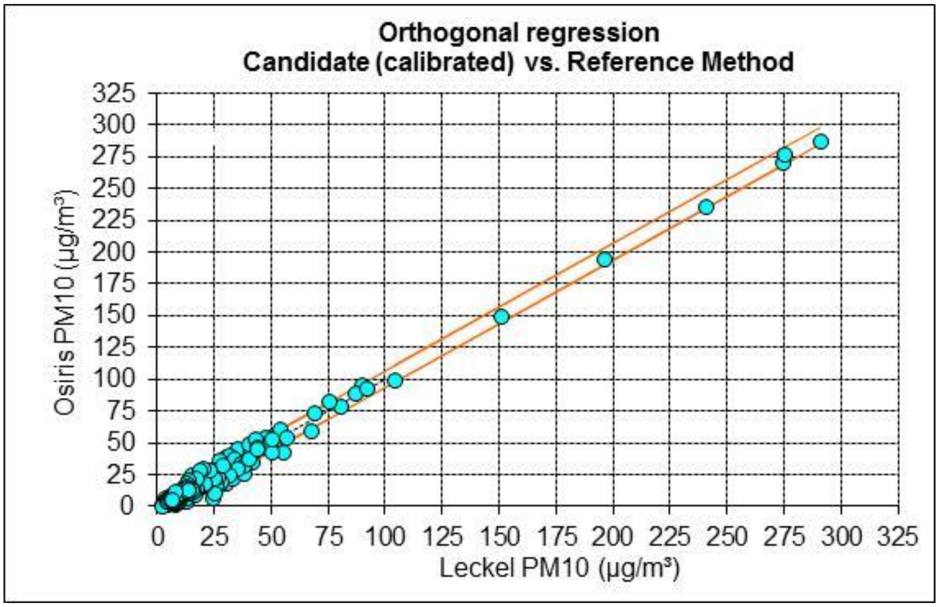

Figure A7.2. Scatter plot of Osiris versus the RMs: Calibrated data

Table A7.1. Equivalence test results for Osiris against the RMs for PM_{10}, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	1,401y + -0,153		N (Spring)	142	n
Regression (i=0)	1,398y		N (Summer)	73	n
N	284	n	N (Fall)	0	n
			N (Winter)	69	n
Outliers	15	n	Outliers	31	n
Outliers	5,3%	%	Outliers	10,9%	%
Mean CM	15,9	µg/m³	Mean CM	22,132	µg/m³
Mean RM	22,1	µg/m³	Mean RM	22,132	µg/m³
Number of RM > 0,6 * LV	48	n	Number of CM > 0,6 * LV	48	n
Number of RM > LV	19	n	Number of CM > LV	21	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**0,71389**	significant	**Slope b**	1,002	
Uncertainty of b	0,005		Uncertainty of b	0,007	
Intercept a	**0,10954**		**Intercept a**	-0,045	
Uncertainty of a	0,200		Uncertainty of a	0,281	
r^2	0,988		r^2	0,988	
Slope b forced trough origin	**0,715**	significant			
Uncertainty of b (forced)	0,0040				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,31	µg/m³	**Calibration**	**1,401y -0,153**	
Uncertainty of calibration (forced)	0,20	µg/m³	**u(calibration)**	**0,310**	µg/m³
Random term	2,71	µg/m³	Random term	3,93	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	-14,20	µg/m³	Bias at LV	0,06	µg/m³
Combined uncertainty	14,45	µg/m³	Combined uncertainty	3,93	µg/m³
Expanded relative uncertainty	**57,8%**	**fail**	**Expanded relative uncertainty**	**15,7%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	50	µg/m³	Limit value	50	µg/m³

A8. PM_{10} equivalence tests for SHARP beta signal

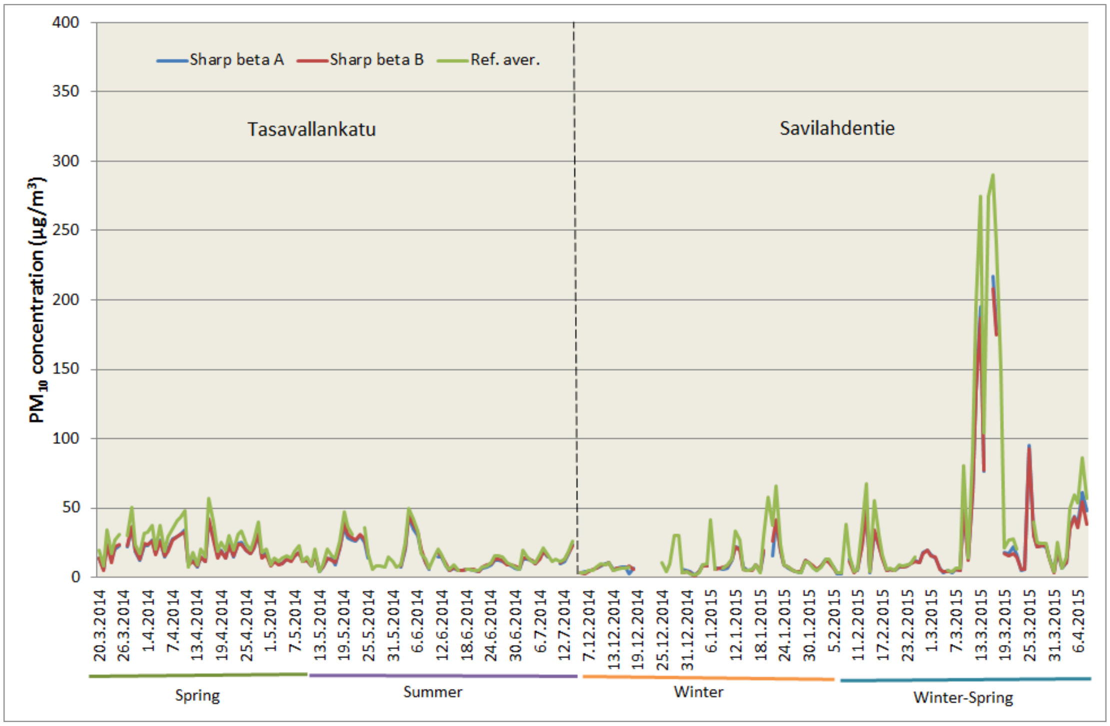

Figure A8.1: Time series of 24 h concentration values of SHARP beta signal and the RMs during the PM_{10} equivalence campaigns in Kuopio.

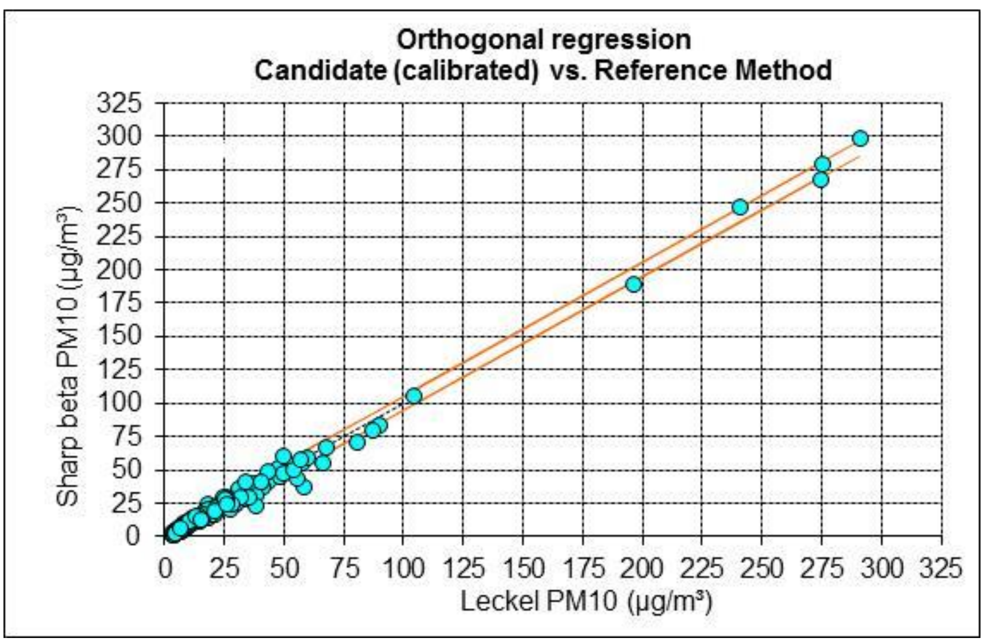

Figure A8.2. Scatter plot of SHARP beta signal versus the RMs: Calibrated data

Table A8.1. Equivalence test results for SHARP beta signal against the RMs for PM_{10}, all data

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**1,415y + -2,233**		N (Spring)	72	n
Regression (i=0)	**1,38y**		N (Summer)	50	n
N	203	n	N (Fall)	12	n
			N (Winter)	69	n
Outliers	9	n	Outliers	18	n
Outliers	4,4%	%	Outliers	8,9%	%
Mean CM	19,7	µg/m³	Mean CM	25,615	µg/m³
Mean RM	25,6	µg/m³	Mean RM	25,615	µg/m³
Number of RM > 0,6 * LV	47	n	Number of CM > 0,6 * LV	46	n
Number of RM > LV	18	n	Number of CM > LV	17	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**0,70662**	**significant**	**Slope b**	1,001	
Uncertainty of b	0,004		Uncertainty of b	0,006	
Intercept a	**1,57753**	**significant**	**Intercept a**	-0,029	
Uncertainty of a	0,196		Uncertainty of a	0,277	
r^2	0,993		r^2	0,993	
Slope b forced trough origin	**0,724**	**significant**			
Uncertainty of b (forced)	0,0040				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,28	µg/m³	**Calibration**	**1,415y -2,233**	
Uncertainty of calibration (forced)	0,20	µg/m³	**u(calibration)**	**0,282**	µg/m³
Random term	2,14	µg/m³	Random term	3,20	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	-13,09	µg/m³	Bias at LV	0,03	µg/m³
Combined uncertainty	13,27	µg/m³	Combined uncertainty	3,20	µg/m³
Expanded relative uncertainty	**53,1%**	**fail**	**Expanded relative uncertainty**	**12,8%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	50	µg/m³	Limit value	50	µg/m³

A9. PM_{10} equivalence tests for SHARP c-dust analyzers

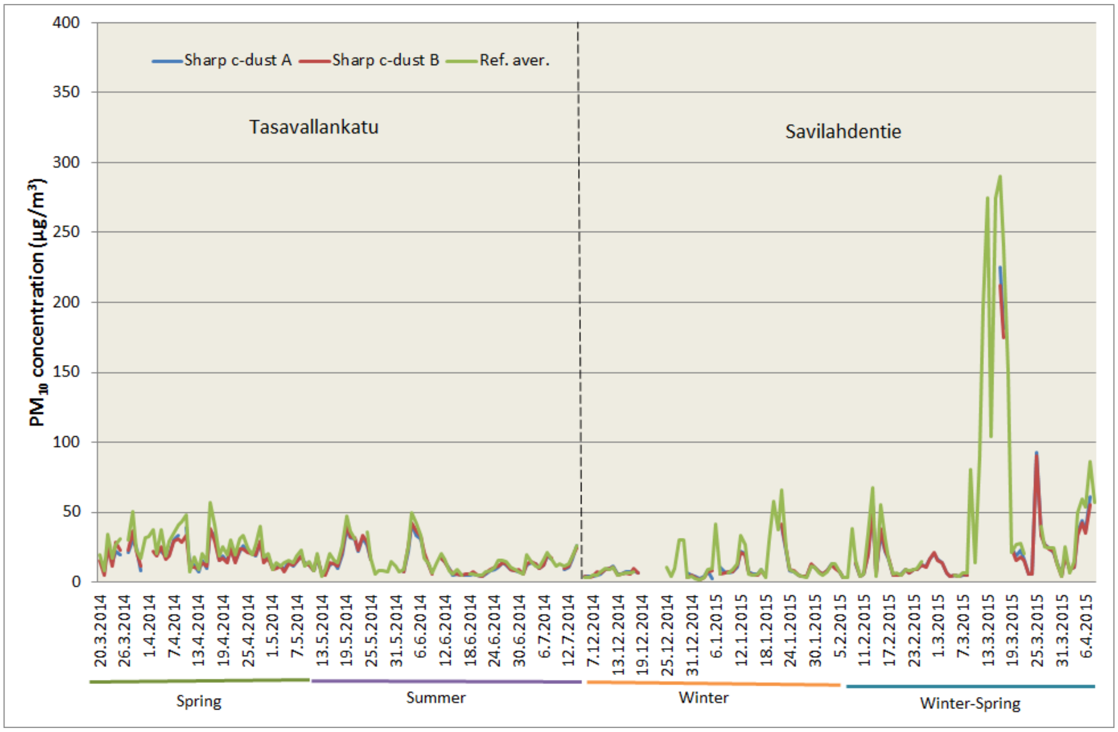

Figure A9.1: Time series of 24 h concentration values of SHARP c-dust and the RMs during the PM10 equivalence campaigns in Kuopio.

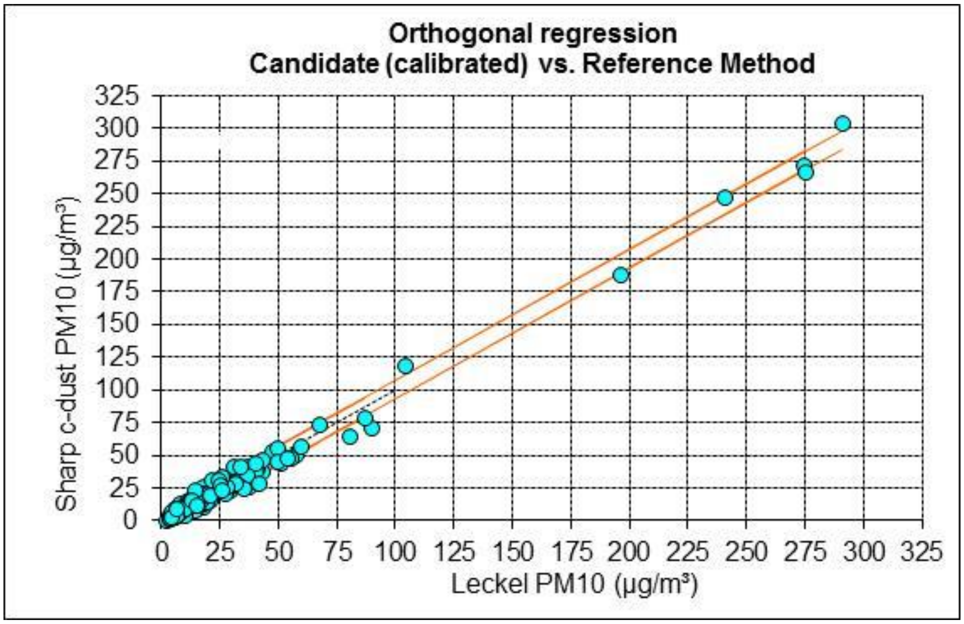

Figure A9.2. Scatter plot of SHARP c-dust versus the RMs: Calibrated data

Table A9.1. Equivalence test results for SHARP c-dust against the RMs for PM_{10}, all data

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**1,404y + -2,75**		N (Spring)	69	n
Regression (i=0)	**1,362y**		N (Summer)	50	n
N	197	n	N (Fall)	12	n
			N (Winter)	66	n
Outliers	9	n	Outliers	19	n
Outliers	4,6%	%	Outliers	9,6%	%
Mean CM	19,8	µg/m³	Mean CM	24,980	µg/m³
Mean RM	25,0	µg/m³	Mean RM	24,980	µg/m³
Number of RM > 0,6 * LV	41	n	Number of CM > 0,6 * LV	41	n
Number of RM > LV	15	n	Number of CM > LV	14	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**0,71223**	significant	**Slope b**	1,002	
Uncertainty of b	0,005		Uncertainty of b	0,008	
Intercept a	**1,95866**	significant	**Intercept a**	-0,046	
Uncertainty of a	0,260		Uncertainty of a	0,366	
r^2	0,989		r^2	0,989	
Slope b forced trough origin	**0,734**	significant			
Uncertainty of b (forced)	0,0053				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,38	µg/m³	**Calibration**	**1,404y -2,750**	
Uncertainty of calibration (forced)	0,26	µg/m³	**u(calibration)**	**0,376**	µg/m³
Random term	2,96	µg/m³	Random term	4,29	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	-12,43	µg/m³	Bias at LV	0,05	µg/m³
Combined uncertainty	12,78	µg/m³	Combined uncertainty	4,29	µg/m³
Expanded relative uncertainty	**51,1%**	**fail**	**Expanded relative uncertainty**	**17,2%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	50	µg/m³	Limit value	50	µg/m³

A10. PM$_{10}$ equivalence tests for TEOM analyzers

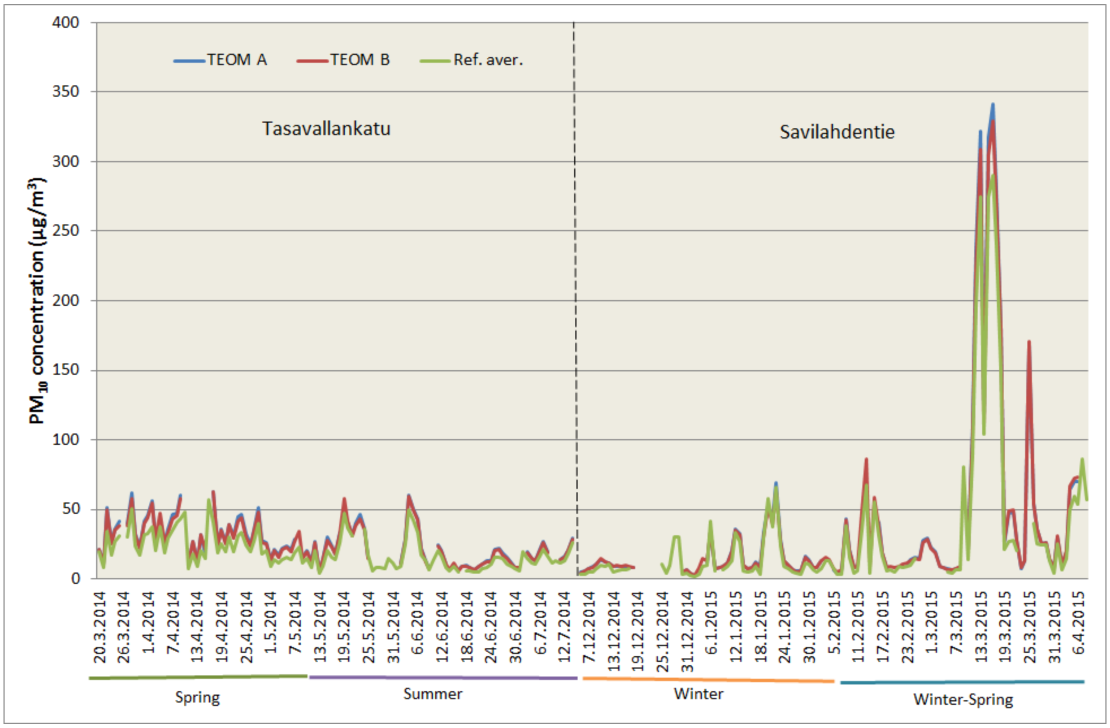

Figure A10.1: Time series of 24 h concentration values of TEOM and the RMs during the PM$_{10}$ equivalence campaigns in Kuopio.

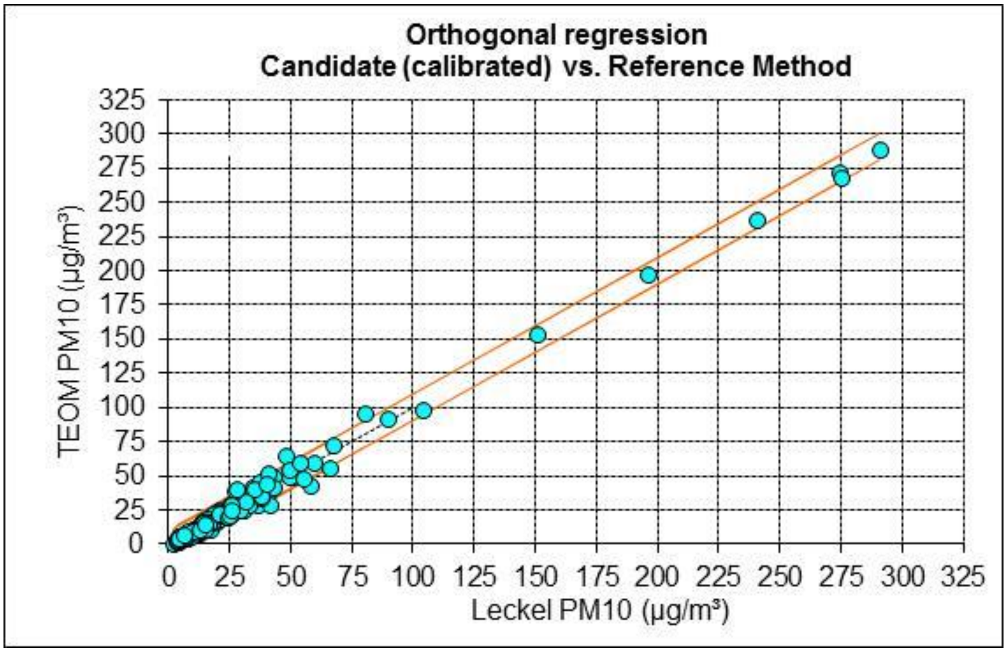

Figure A10.2: Scatter plot of TEOM versus the RMs: Calibrated data.

Table A10.1. Equivalence test results for TEOM against the RMs for PM$_{10}$, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**0,868y + -2,068**		N (Spring)	69	n
Regression (i=0)	**0,848y**		N (Summer)	46	n
N	194	n	N (Fall)	11	n
			N (Winter)	68	n
Outliers	9	n	Outliers	8	n
Outliers	4,6%	%	Outliers	4,1%	%
Mean CM	32,3	µg/m³	Mean CM	25,965	µg/m³
Mean RM	26,0	µg/m³	Mean RM	25,965	µg/m³
Number of RM > 0,6 * LV	44	n	Number of CM > 0,6 * LV	43	n
Number of RM > LV	16	n	Number of CM > LV	16	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**1,15264**	**significant**	**Slope b**	0,999	
Uncertainty of b	0,007		Uncertainty of b	0,006	
Intercept a	**2,38402**	**significant**	**Intercept a**	0,014	
Uncertainty of a	0,358		Uncertainty of a	0,311	
r^2	0,992		r^2	0,992	
Slope b forced trough origin	**1,179**	**significant**			
Uncertainty of b (forced)	0,0069				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,51	µg/m³	**Calibration**	**0,868y -2,068**	
Uncertainty of calibration (forced)	0,34	µg/m³	**u(calibration)**	**0,509**	µg/m³
Random term	4,13	µg/m³	Random term	3,59	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	10,02	µg/m³	Bias at LV	-0,01	µg/m³
Combined uncertainty	10,84	µg/m³	Combined uncertainty	3,59	µg/m³
Expanded relative uncertainty	**43,3%**	**fail**	**Expanded relative uncertainty**	**14,4%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	50	µg/m³	Limit value	50	µg/m³

A11: Calibration factors for CM for each PM_{10} campaign

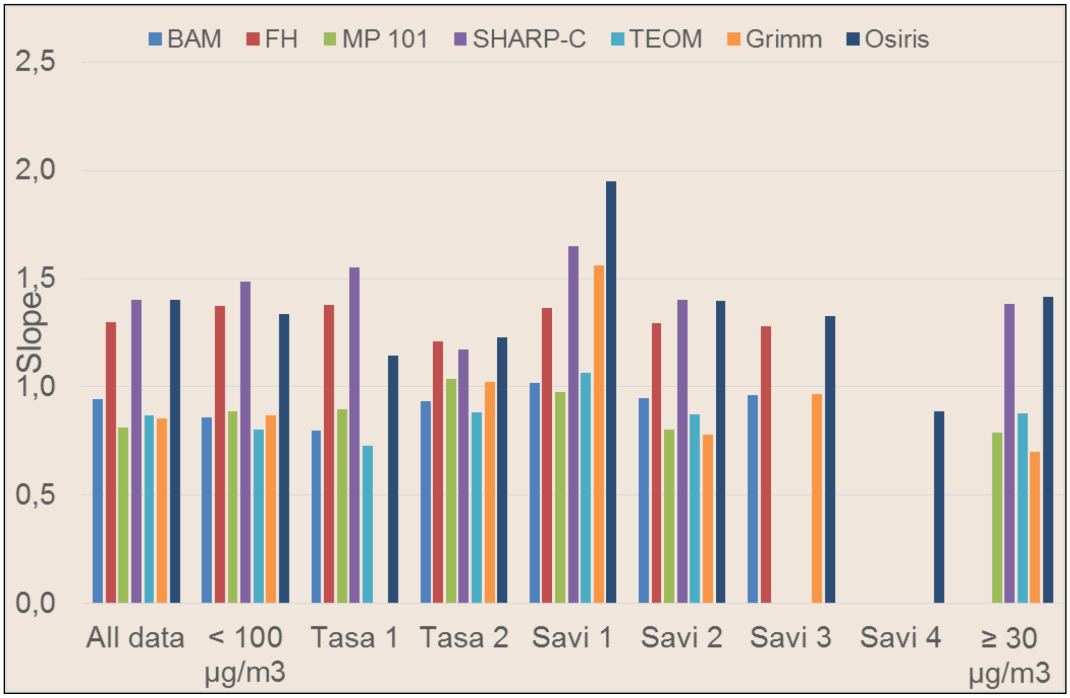

Figure A11.1: Slopes of the calibration equations for each CM at each campaign.

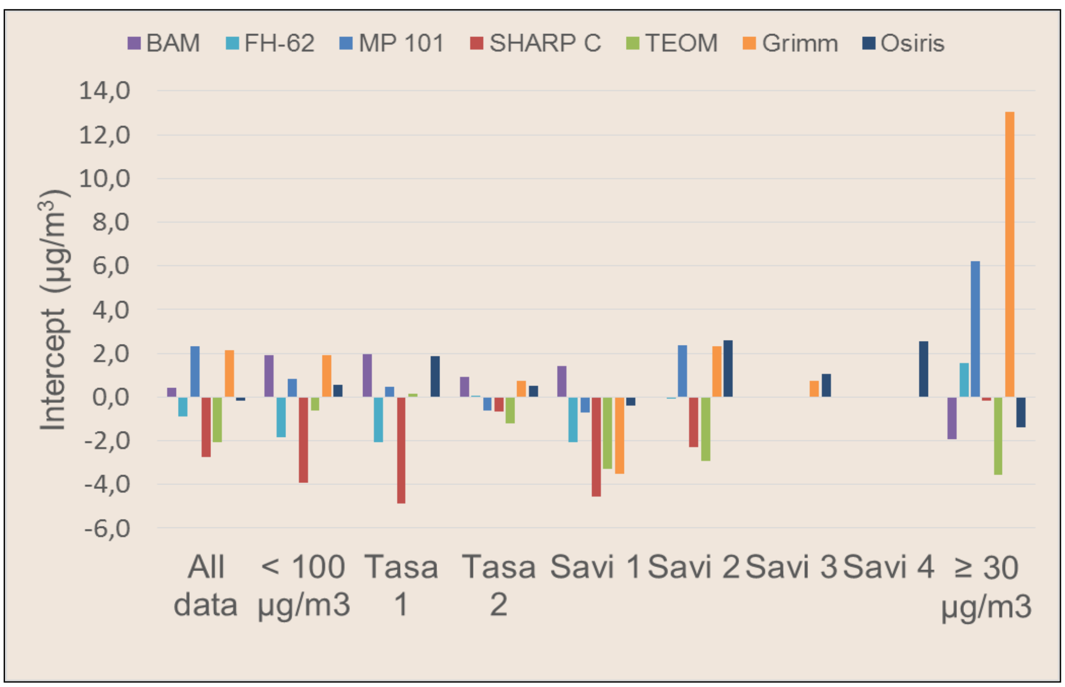

Figure A11.2: Intercepts for each CM for each campaign.

A12. PM2.5 equivalence tests for BAM analyzers

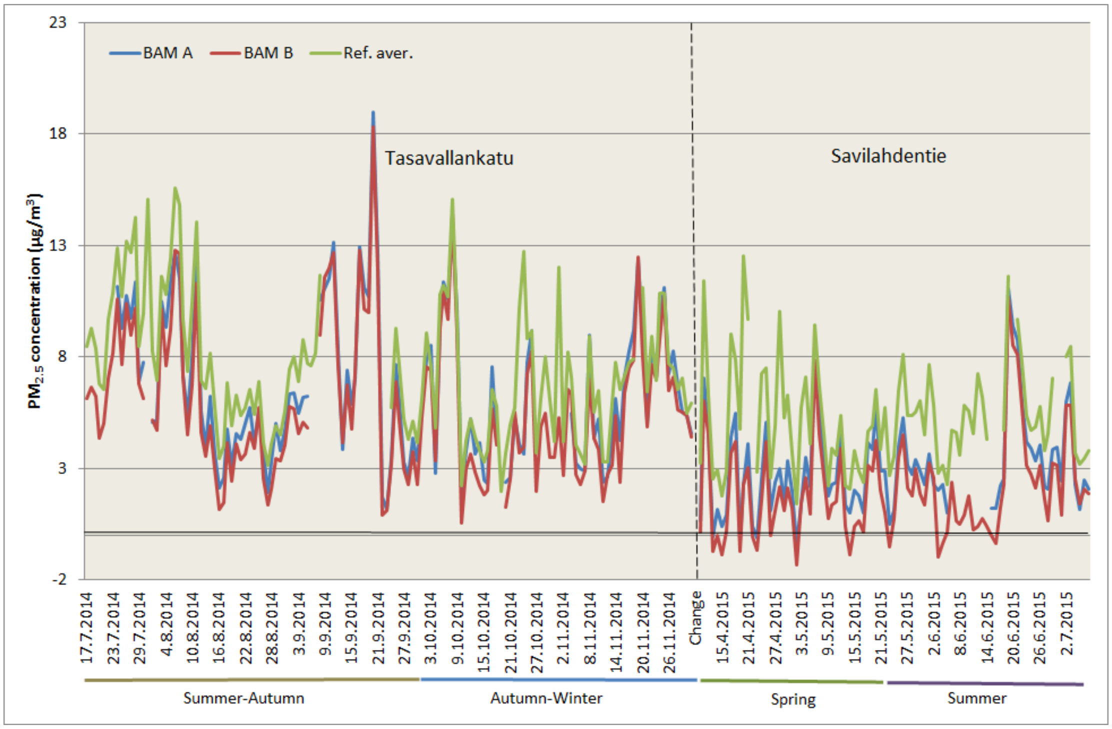

Figure A12.1: Time series of 24 h concentration values of BAM and the RMs during the $PM_{2.5}$ equivalence campaigns in Kuopio.

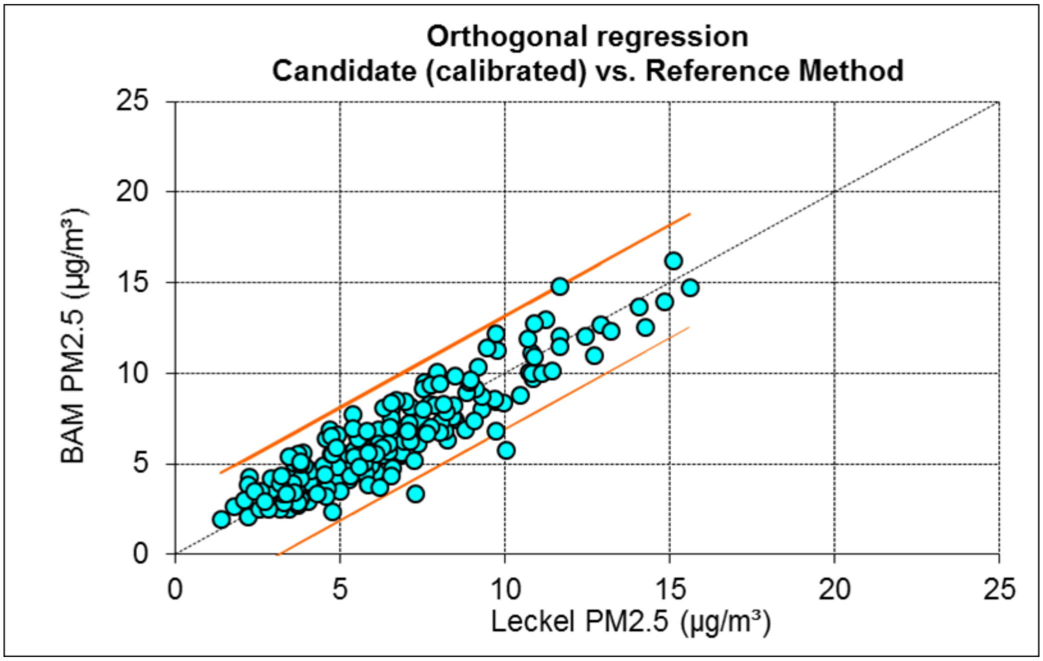

Figure A12.2: Scatter plot of BAM versus the RMs: Calibrated data.
Table A12.1. Equivalence test results for BAM against the RMs for $PM_{2.5}$, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**1,1y + 0,733**		N (Spring)	50	n
Regression (i=0)	**1,215y**		N (Summer)	75	n
N	195	n	N (Fall)	69	n
			N (Winter)	1	n
Outliers	4	n	Outliers	3	n
Outliers	2,1%	%	Outliers	1,5%	%
Mean CM	5,2	µg/m³	Mean CM	6,497	µg/m³
Mean RM	6,5	µg/m³	Mean RM	6,497	µg/m³
Number of RM > 0,6 * LV	0	n	Number of CM > 0,6 * LV	0	n
Number of RM > LV	0	n	Number of CM > LV	0	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**0,90941**	significant	**Slope b**	1,009	
Uncertainty of b	0,027		Uncertainty of b	0,030	
Intercept a	**-0,66676**	significant	**Intercept a**	-0,059	
Uncertainty of a	0,192		Uncertainty of a	0,211	
r^2	0,832		r^2	0,832	
Slope b forced trough origin	**0,823**	significant			
Uncertainty of b (forced)	0,0109				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,83	µg/m³	**Calibration**	**1,100y + 0,733**	
Uncertainty of calibration (forced)	0,33	µg/m³	**u(calibration)**	**0,833**	µg/m³
Random term	0,47	µg/m³	Random term	1,09	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	-3,38	µg/m³	Bias at LV	0,21	µg/m³
Combined uncertainty	3,42	µg/m³	Combined uncertainty	1,11	µg/m³
Expanded relative uncertainty	**22,8%**	***pass***	**Expanded relative uncertainty**	**7,4%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	30	µg/m³	Limit value	30	µg/m³

A13. PM2.5 equivalence tests for DustTrak analyzers

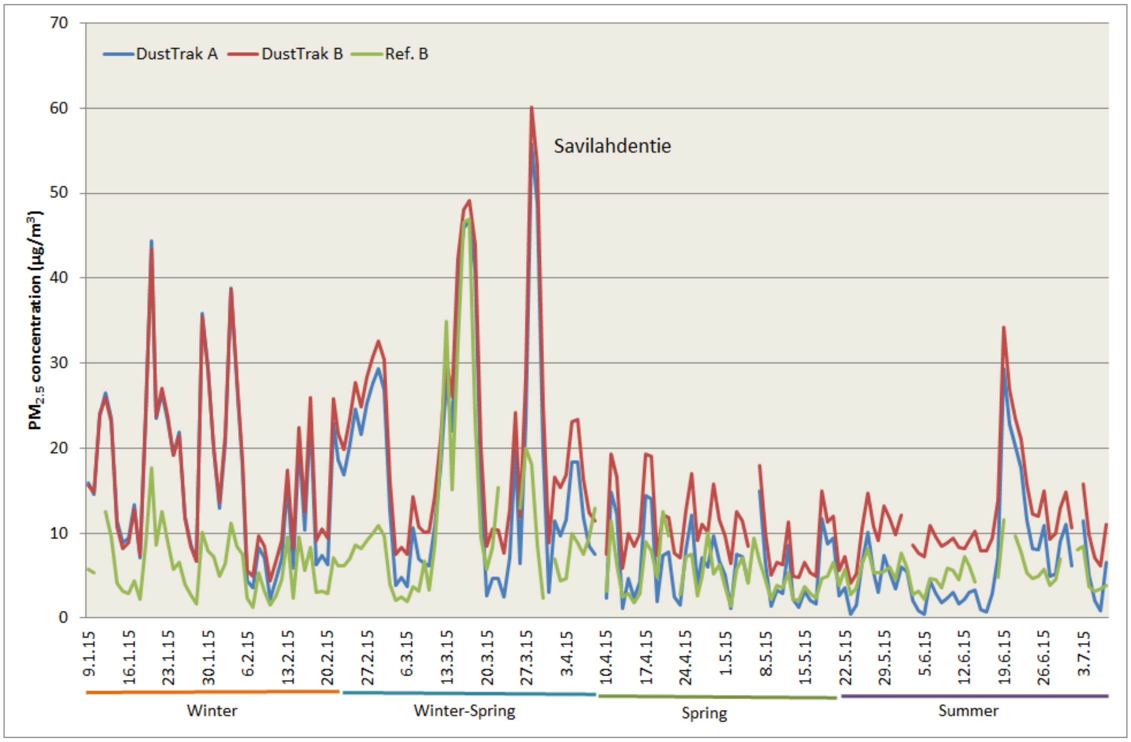

Figure A13.1: Time series of 24 h concentration values of DustTrak and the RMs during the $PM_{2.5}$ equivalence campaigns in Kuopio.

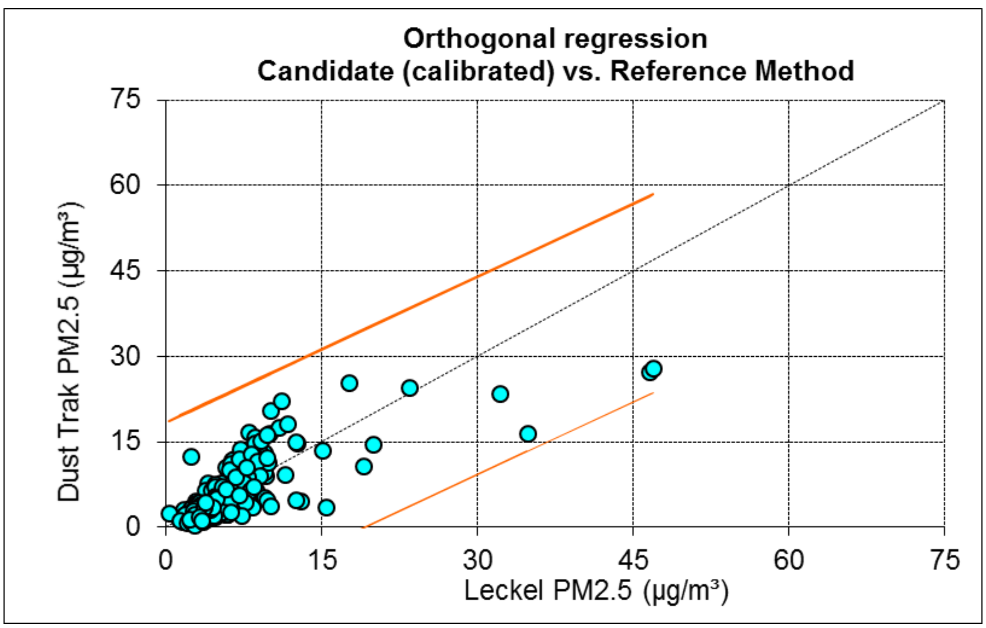

Figure A13.2: Scatter plot of DustTrak versus the RMs: Calibrated data.

Table A13.1. Equivalence test results for DustTrak against the RMs for $PM_{2.5}$, all data

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	0,602y + -1,002		N (Spring)	83	n
Regression (i=0)	0,55y		N (Summer)	31	n
N	164	n	N (Fall)	0	n
			N (Winter)	50	n
Outliers	7	n	Outliers	0	n
Outliers	4,3%	%	Outliers	0,0%	%
Mean CM	13,2	µg/m³	Mean CM	6,956	µg/m³
Mean RM	7,0	µg/m³	Mean RM	6,956	µg/m³
Number of RM > 0,6 * LV	7	n	Number of CM > 0,6 * LV	8	n
Number of RM > LV	4	n	Number of CM > LV	0	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**1,66217**	significant	**Slope b**	0,853	significant
Uncertainty of b	0,077		Uncertainty of b	0,046	
Intercept a	**1,66540**	significant	**Intercept a**	1,024	significant
Uncertainty of a	0,727		Uncertainty of a	0,437	
r^2	0,564		r^2	0,564	
Slope b forced trough origin	**1,820**	significant			
Uncertainty of b (forced)	0,0605				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	2,41	µg/m³	**Calibration**	**0,602y -1,002**	
Uncertainty of calibration (forced)	1,82	µg/m³	**u(calibration)**	**2,408**	µg/m³
Random term	7,23	µg/m³	Random term	4,56	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	21,53	µg/m³	Bias at LV	-3,39	µg/m³
Combined uncertainty	22,71	µg/m³	Combined uncertainty	5,69	µg/m³
Expanded relative uncertainty	**151,4%**	**fail**	**Expanded relative uncertainty**	**37,9%**	**fail**
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	30	µg/m³	Limit value	30	µg/m³

A14. PM2.5 equivalence tests for FH 62 I-R analyzers

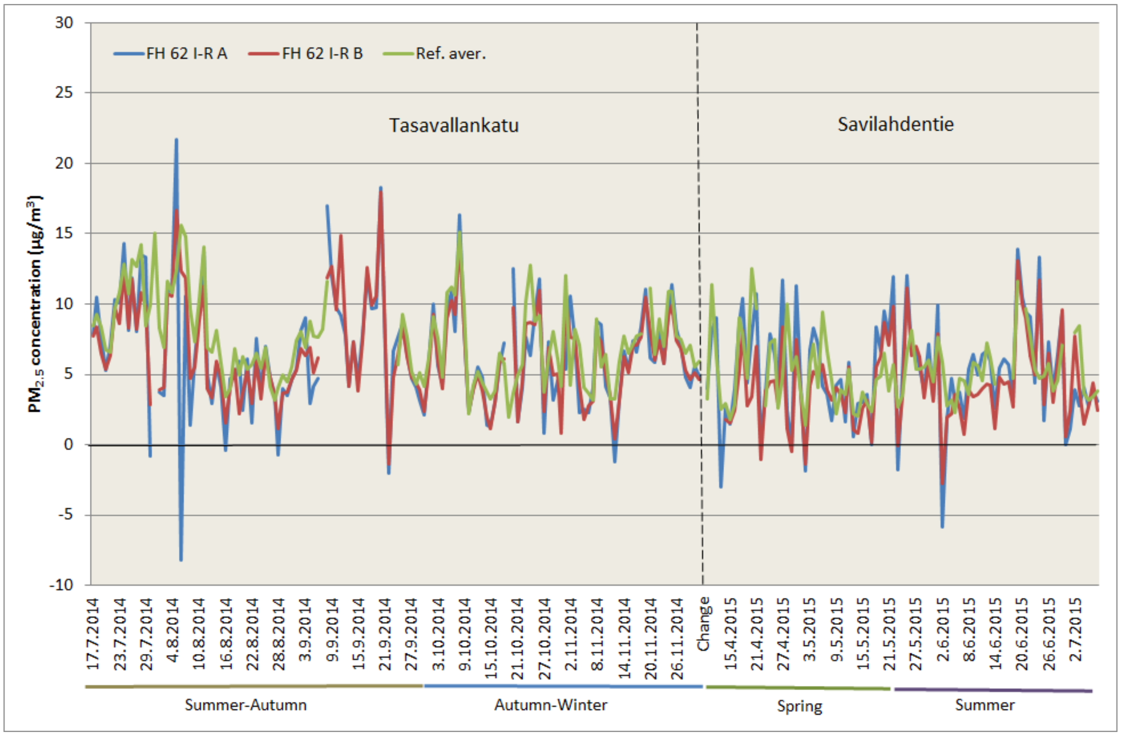

Figure A14.1: Time series of 24 h concentration values of FH 62 I-R and the RMs during the $PM_{2.5}$ equivalence campaigns in Kuopio.

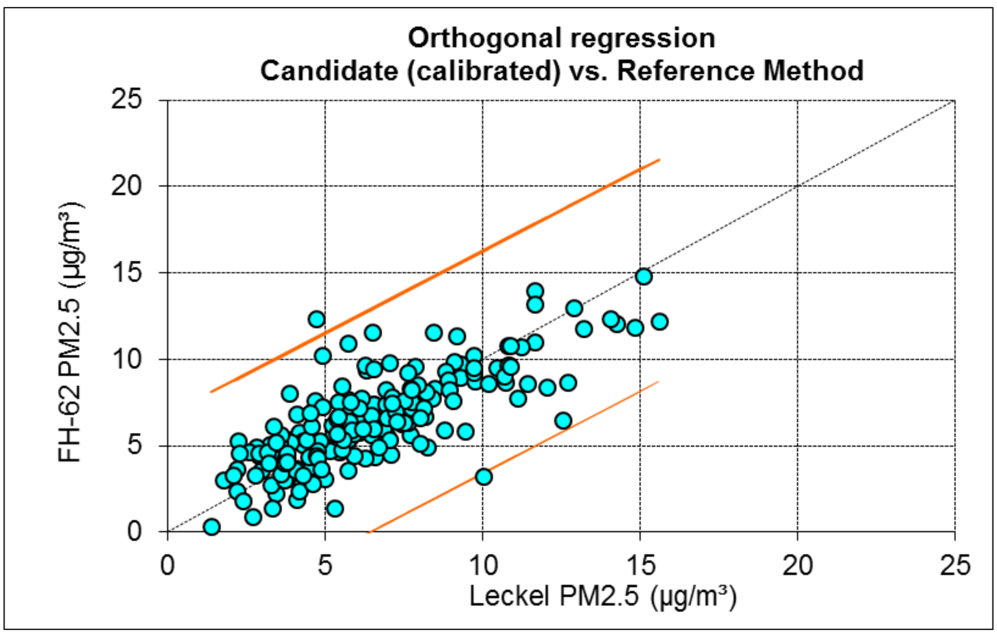

Figure A14.2: Scatter plot of FH 62 I-R versus the RMs: Calibrated data.

Table A14.1. Equivalence test results for FH 62 I-R against the RMs for $PM_{2.5}$, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**0,85y + 1,709**		N (Spring)	51	n
Regression (i=0)	**1,097y**		N (Summer)	73	n
N	195	n	N (Fall)	70	n
			N (Winter)	1	n
Outliers	7	n	Outliers	3	n
Outliers	3,6%	%	Outliers	1,5%	%
Mean CM	5,6	µg/m³	Mean CM	6,492	µg/m³
Mean RM	6,5	µg/m³	Mean RM	6,492	µg/m³
Number of RM > 0,6 * LV	0	n	Number of CM > 0,6 * LV	0	n
Number of RM > LV	0	n	Number of CM > LV	0	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**1,17657**	significant	**Slope b**	0,950	
Uncertainty of b	0,053		Uncertainty of b	0,045	
Intercept a	**-2,01057**	significant	**Intercept a**	0,322	
Uncertainty of a	0,376		Uncertainty of a	0,320	
r^2	0,578		r^2	0,578	
Slope b forced trough origin	**0,912**	significant			
Uncertainty of b (forced)	0,0216				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	1,63	µg/m³	**Calibration**	**0,850y + 1,709**	
Uncertainty of calibration (forced)	0,65	µg/m³	**u(calibration)**	**1,632**	µg/m³
Random term	2,11	µg/m³	Random term	2,32	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	3,29	µg/m³	Bias at LV	-1,17	µg/m³
Combined uncertainty	3,91	µg/m³	Combined uncertainty	2,60	µg/m³
Expanded relative uncertainty	**26,0%**	**fail**	**Expanded relative uncertainty**	**17,3%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	30	µg/m³	Limit value	30	µg/m³

A15. $PM_{2.5}$ equivalence tests for Grimm analyzers

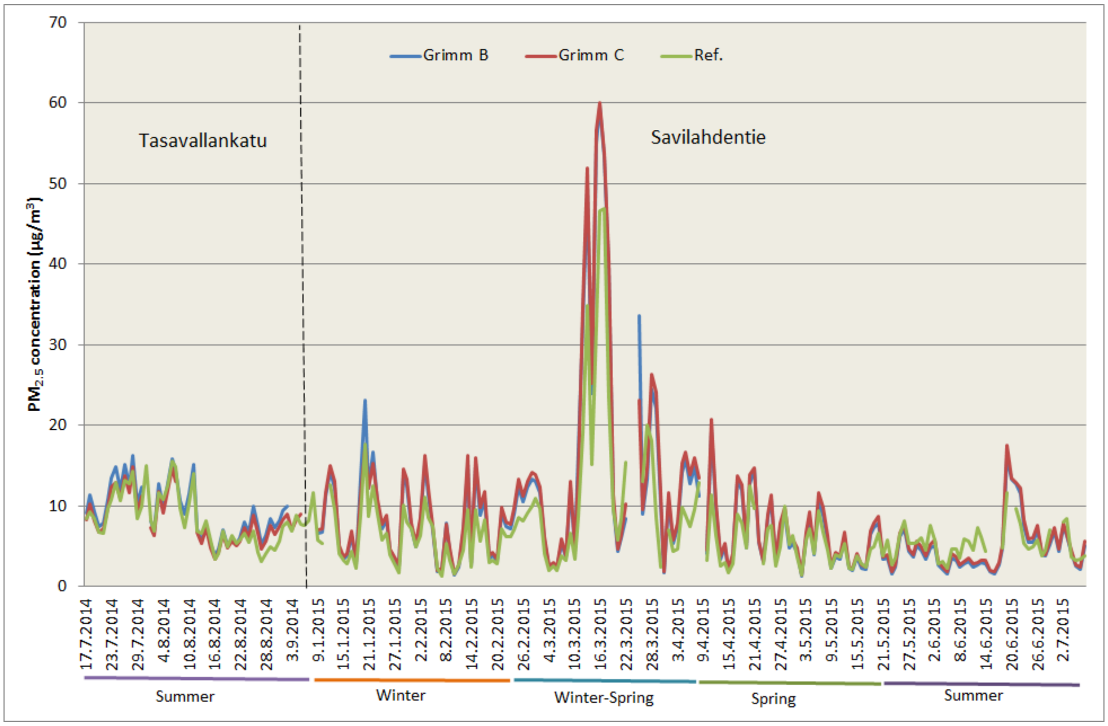

Figure A15.1: Time series of 24 h concentration values of Grimm and the RMs during the $PM_{2.5}$ equivalence campaigns in Kuopio.

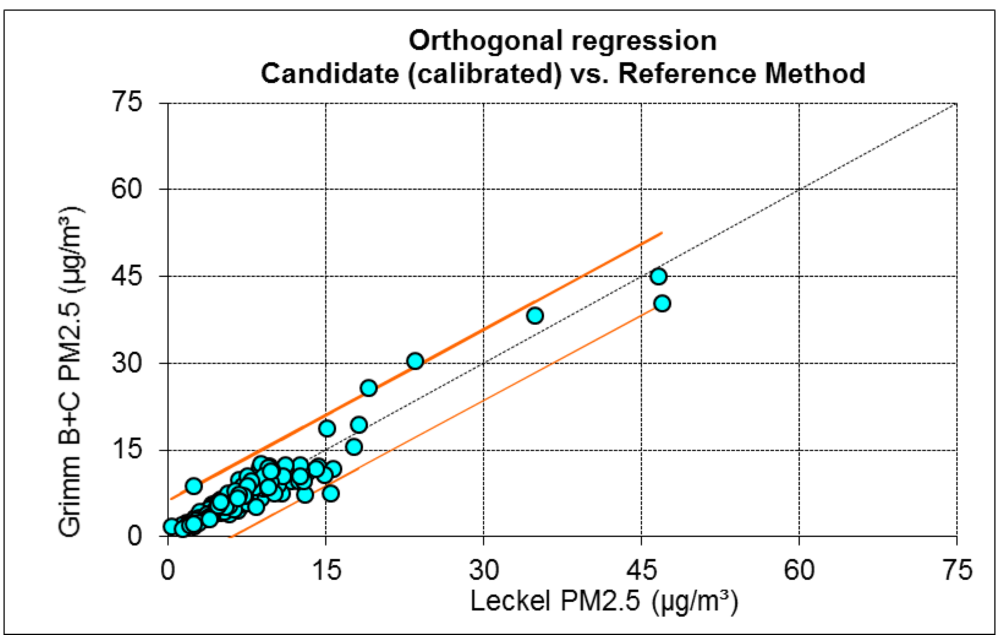

Figure A15.2: Scatter plot of Grimm versus the RMs: Calibrated data.
Table A15.1. Equivalence test results for Grimm against the RMs for $PM_{2.5}$, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**0,747y + 0,532**		N (Spring)	73	n
Regression (i=0)	**0,78y**		N (Summer)	45	n
N	173	n	N (Fall)	5	n
			N (Winter)	50	n
Outliers	6	n	Outliers	4	n
Outliers	3,5%	%	Outliers	2,3%	%
Mean CM	9,4	µg/m³	Mean CM	7,586	µg/m³
Mean RM	7,6	µg/m³	Mean RM	7,586	µg/m³
Number of RM > 0,6 * LV	6	n	Number of CM > 0,6 * LV	7	n
Number of RM > LV	3	n	Number of CM > LV	4	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**1,33912**	significant	**Slope b**	0,986	
Uncertainty of b	0,031		Uncertainty of b	0,023	
Intercept a	**-0,71199**	significant	**Intercept a**	0,108	
Uncertainty of a	0,301		Uncertainty of a	0,225	
r^2	0,907		r^2	0,907	
Slope b forced trough origin	**1,282**	significant			
Uncertainty of b (forced)	0,0193				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,97	µg/m³	**Calibration**	**0,747y + 0,532**	
Uncertainty of calibration (forced)	0,58	µg/m³	**u(calibration)**	**0,974**	µg/m³
Random term	2,32	µg/m³	Random term	1,86	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	9,46	µg/m³	Bias at LV	-0,32	µg/m³
Combined uncertainty	9,74	µg/m³	Combined uncertainty	1,89	µg/m³
Expanded relative uncertainty	**65,0%**	**fail**	**Expanded relative uncertainty**	**12,6%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	30	µg/m³	Limit value	30	µg/m³

A16. PM$_{2.5}$ equivalence tests for Environnement MP101 analyzers

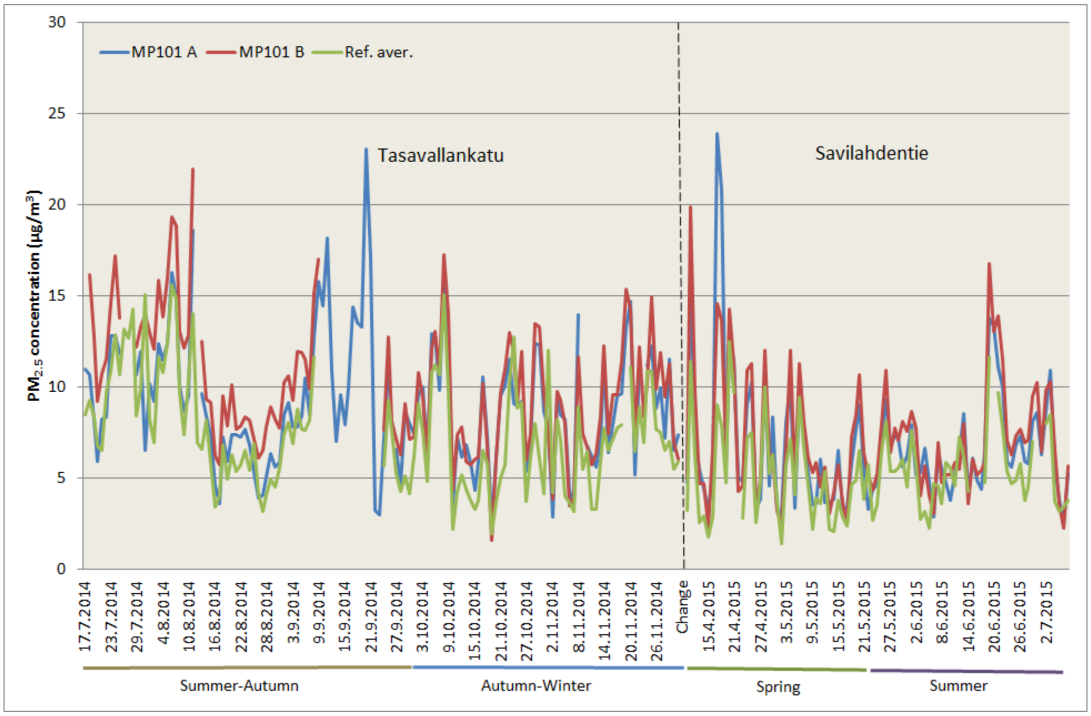

Figure A16.1: Time series of 24 h concentration values of MP101 and the RMs during the PM$_{2.5}$ equivalence campaigns in Kuopio.

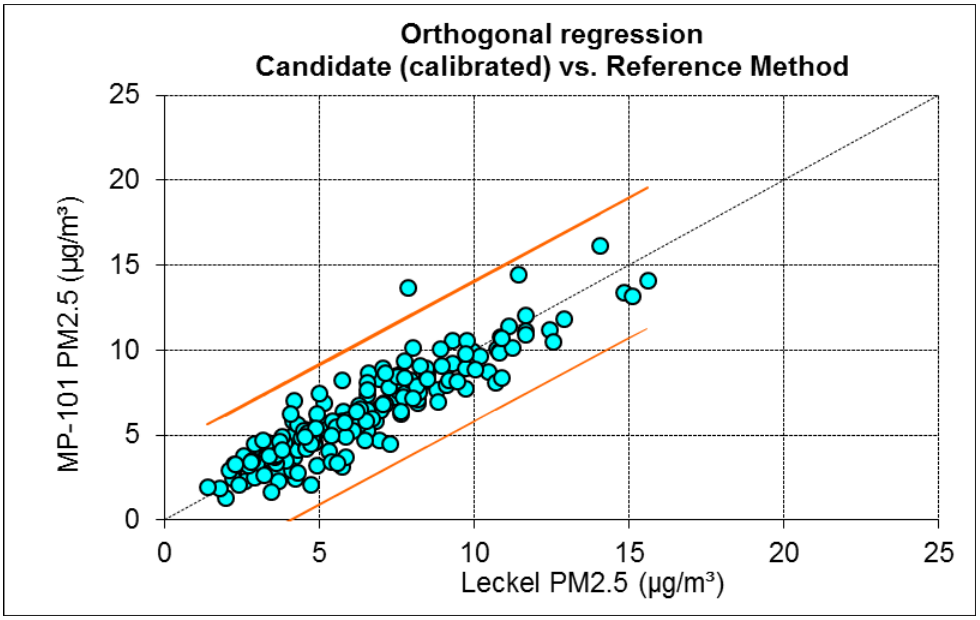

Figure A16.2: Scatter plot of MP101 versus the RMs: Calibrated data.

Table A16.1. Equivalence test results for MP101 against the RMs for PM$_{2.5}$, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**0,812y + -0,306**		N (Spring)	50	n
Regression (i=0)	**0,78y**		N (Summer)	73	n
N	196	n	N (Fall)	72	n
			N (Winter)	1	n
Outliers	4	n	Outliers	1	n
Outliers	2,0%	%	Outliers	0,5%	%
Mean CM	8,2	µg/m³	Mean CM	6,379	µg/m³
Mean RM	6,4	µg/m³	Mean RM	6,379	µg/m³
Number of RM > 0,6 * LV	0	n	Number of CM > 0,6 * LV	0	n
Number of RM > LV	0	n	Number of CM > LV	0	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**1,23166**	significant	**Slope b**	0,980	
Uncertainty of b	0,036		Uncertainty of b	0,029	
Intercept a	**0,37721**		**Intercept a**	0,126	
Uncertainty of a	0,249		Uncertainty of a	0,202	
r^2	0,831		r^2	0,831	
Slope b forced trough origin	**1,282**	significant			
Uncertainty of b (forced)	0,0152				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	1,10	µg/m³	**Calibration**	**0,812y -0,306**	
Uncertainty of calibration (forced)	0,46	µg/m³	**u(calibration)**	**1,099**	µg/m³
Random term	1,06	µg/m³	Random term	1,26	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	7,33	µg/m³	Bias at LV	-0,47	µg/m³
Combined uncertainty	7,40	µg/m³	Combined uncertainty	1,34	µg/m³
Expanded relative uncertainty	**49,4%**	**fail**	**Expanded relative uncertainty**	**8,9%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	30	µg/m³	Limit value	30	µg/m³

A17. PM2.5 equivalence tests for Osiris analyzers

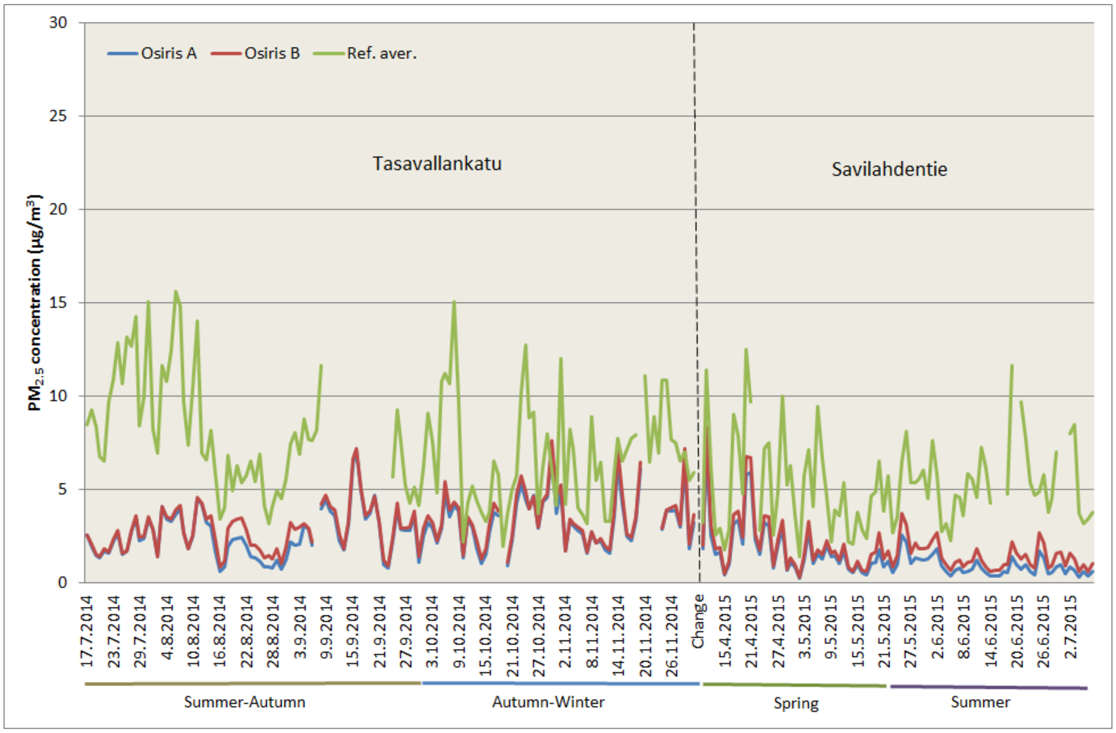

Figure A17.1: Time series of 24 h concentration values of Osiris and the RMs during the PM2.5 equivalence campaigns in Kuopio.

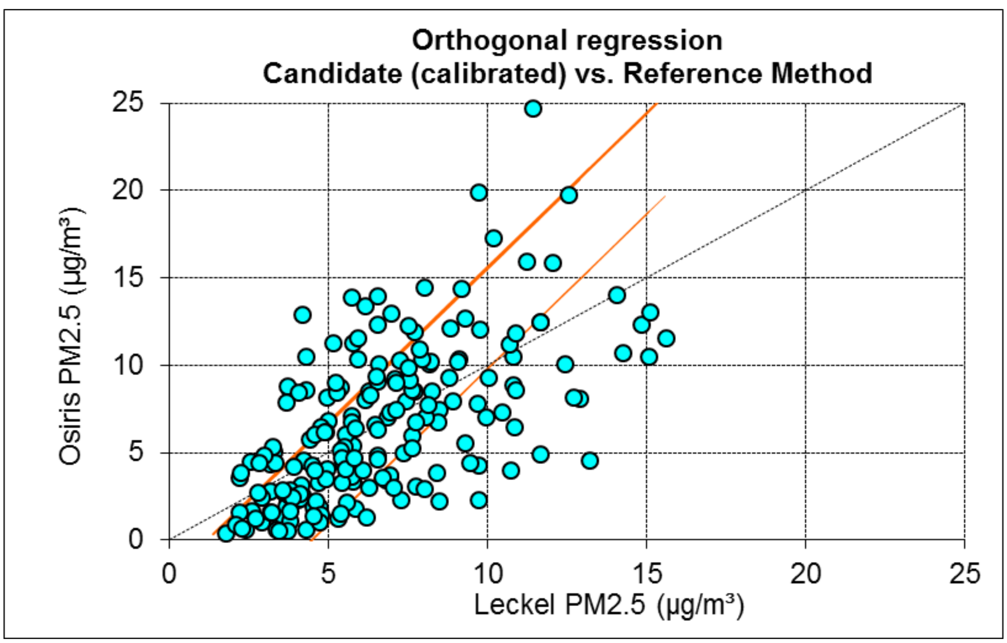

Figure A17.2: Scatter plot of Osiris versus the RMs: Calibrated data.
Table A17.1. Equivalence test results for Osiris against the RMs for PM2.5, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	3,324y + -1,073		N (Spring)	51	n
Regression (i=0)	2,92y		N (Summer)	78	n
N	195	n	N (Fall)	65	n
			N (Winter)	1	n
Outliers	5	n	Outliers	87	n
Outliers	2,6%	%	Outliers	44,6%	%
Mean CM	2,3	µg/m³	Mean CM	6,539	µg/m³
Mean RM	6,5	µg/m³	Mean RM	6,539	µg/m³
Number of RM > 0,6 * LV	0	n	Number of CM > 0,6 * LV	3	n
Number of RM > LV	0	n	Number of CM > LV	0	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**0,30086**	significant	**Slope b**	1,773	significant
Uncertainty of b	0,025		Uncertainty of b	0,082	
Intercept a	**0,32292**		**Intercept a**	-5,054	significant
Uncertainty of a	0,177		Uncertainty of a	0,587	
r^2	0,383		r^2	0,383	
Slope b forced trough origin	**0,343**	significant			
Uncertainty of b (forced)	0,0105				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,76	µg/m³	**Calibration**	**3,324y -1,073**	
Uncertainty of calibration (forced)	0,31	µg/m³	**u(calibration)**	**0,757**	µg/m³
Random term	0,27	µg/m³	Random term	4,29	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	-20,65	µg/m³	Bias at LV	18,13	µg/m³
Combined uncertainty	20,65	µg/m³	Combined uncertainty	18,63	µg/m³
Expanded relative uncertainty	**137,7%**	**fail**	**Expanded relative uncertainty**	**124,2%**	**fail**
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	30	µg/m³	Limit value	30	µg/m³

A18. $PM_{2.5}$ equivalence tests for SHARP beta analyzers

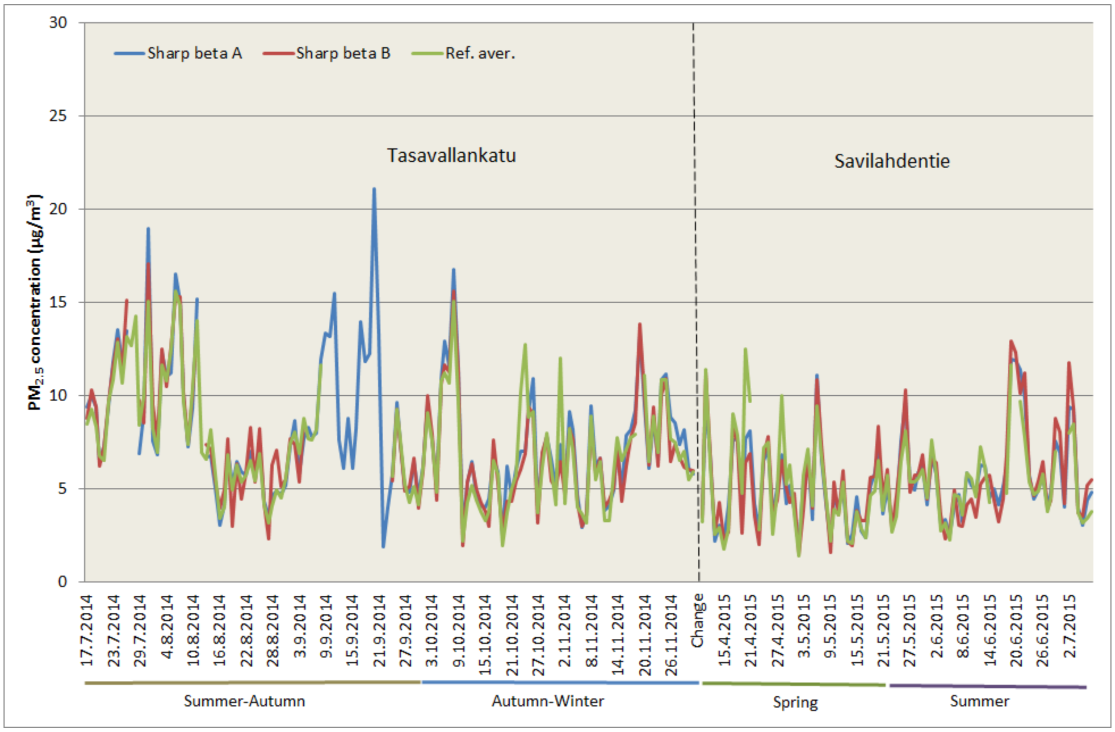

Figure A18.1: Time series of 24 h concentration values of SHARP beta and the RMs during the $PM_{2.5}$ equivalence campaigns in Kuopio.

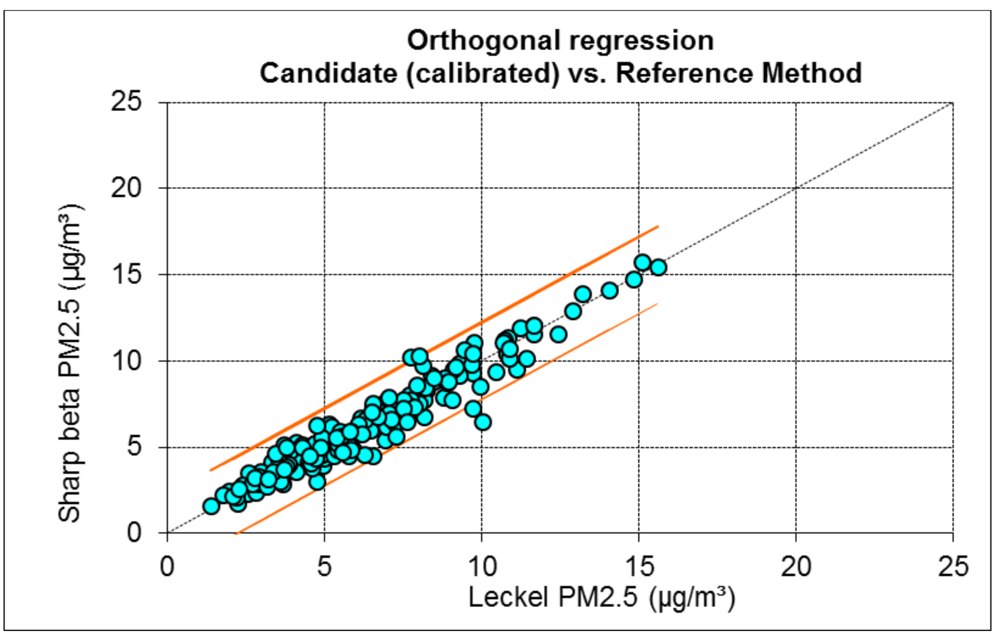

Figure A18.2: Scatter plot of SHARP beta versus the RMs: Calibrated data.

Table A18.1. Equivalence test results for SHARP beta against the RMs for $PM_{2.5}$, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**0,971y + -0,003**		N (Spring)	50	n
Regression (i=0)	**0,971y**		N (Summer)	73	n
N	196	n	N (Fall)	72	n
			N (Winter)	1	n
Outliers	6	n	Outliers	4	n
Outliers	3,1%	%	Outliers	2,0%	%
Mean CM	6,6	µg/m³	Mean CM	6,365	µg/m³
Mean RM	6,4	µg/m³	Mean RM	6,365	µg/m³
Number of RM > 0,6 * LV	0	n	Number of CM > 0,6 * LV	0	n
Number of RM > LV	0	n	Number of CM > LV	0	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**1,02967**		**Slope b**	0,999	
Uncertainty of b	0,020		Uncertainty of b	0,019	
Intercept a	**0,00306**		**Intercept a**	0,007	
Uncertainty of a	0,137		Uncertainty of a	0,133	
r^2	0,929		r^2	0,929	
Slope b forced trough origin	**1,030**	**significant**			
Uncertainty of b (forced)	0,0080				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,61	µg/m³	**Calibration**	**0,971y -0,003**	
Uncertainty of calibration (forced)	0,24	µg/m³	**u(calibration)**	**0,607**	µg/m³
Random term	0,00	µg/m³	Random term	0,00	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	0,89	µg/m³	Bias at LV	-0,03	µg/m³
Combined uncertainty	0,89	µg/m³	Combined uncertainty	0,03	µg/m³
Expanded relative uncertainty	**6,0%**	***pass***	**Expanded relative uncertainty**	**0,2%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	30	µg/m³	Limit value	30	µg/m³

A19. $PM_{2.5}$ equivalence tests for SHARP c-dust analyzers

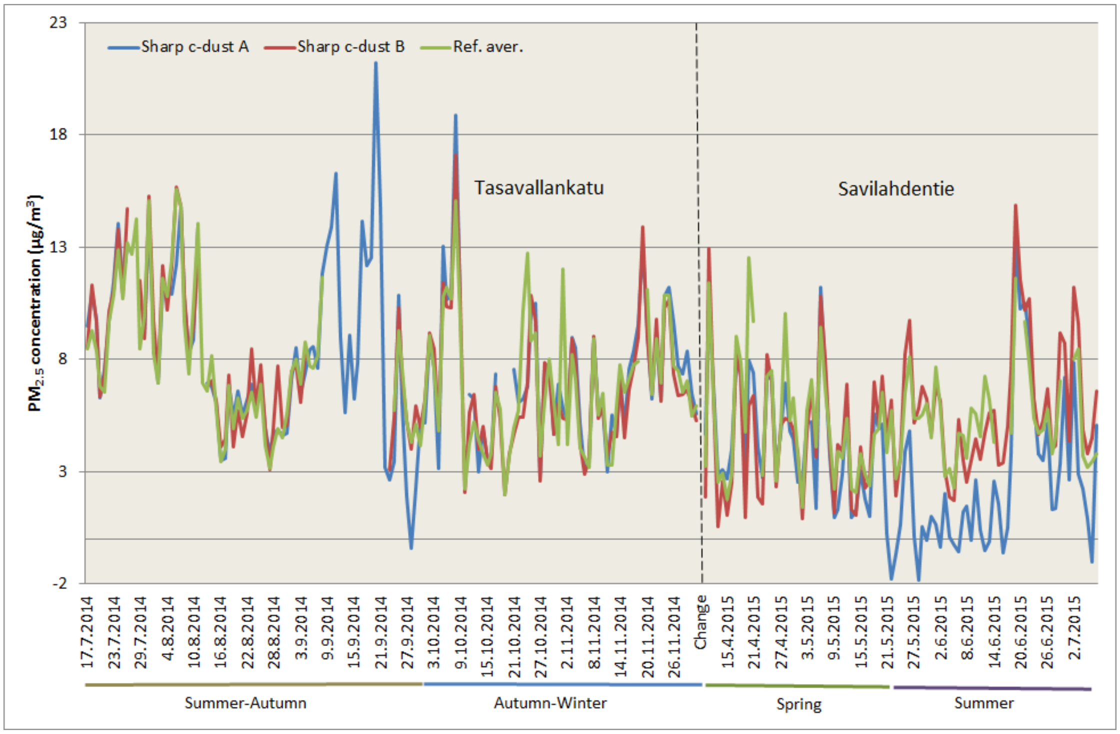

Figure A19.1: Time series of 24 h concentration values of SHARP c-dust and the RMs during the $PM_{2.5}$ equivalence campaigns in Kuopio.

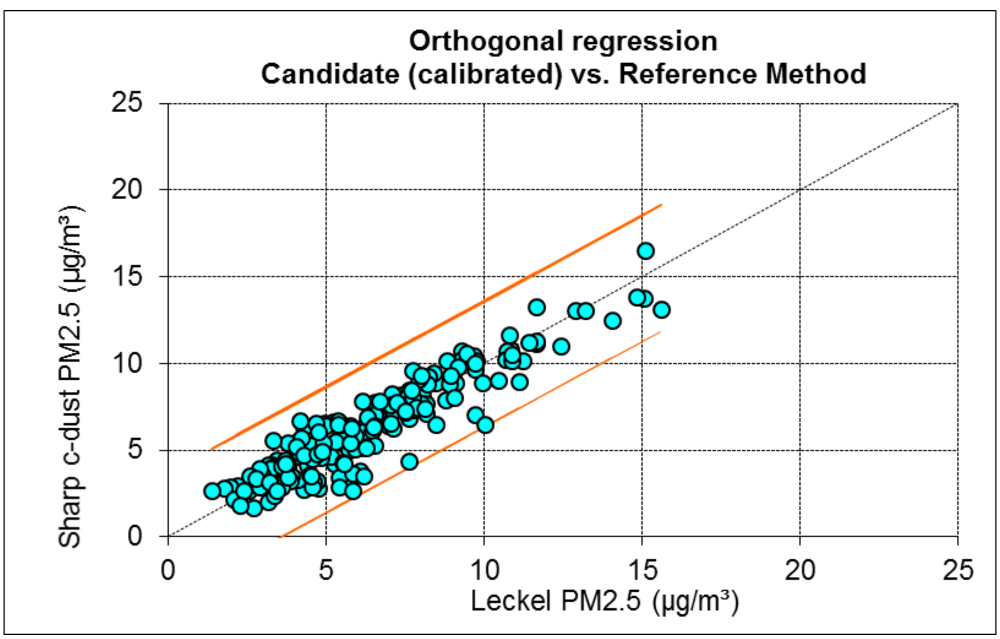

Figure A19.2: Scatter plot of SHARP c-dust versus the RMs: Calibrated data.

Table A19.1. Equivalence test results for SHARP c-dust against the RMs for $PM_{2.5}$, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**0,854y + 1,187**		N (Spring)	50	n
Regression (i=0)	**1,009y**		N (Summer)	72	n
N	195	n	N (Fall)	72	n
			N (Winter)	1	n
Outliers	9	n	Outliers	0	n
Outliers	4,6%	%	Outliers	0,0%	%
Mean CM	6,1	µg/m³	Mean CM	6,418	µg/m³
Mean RM	6,4	µg/m³	Mean RM	6,418	µg/m³
Number of RM > 0,6 * LV	0	n	Number of CM > 0,6 * LV	0	n
Number of RM > LV	0	n	Number of CM > LV	0	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**1,17085**	**significant**	**Slope b**	0,988	
Uncertainty of b	0,031		Uncertainty of b	0,027	
Intercept a	**-1,38994**	**significant**	**Intercept a**	0,078	
Uncertainty of a	0,220		Uncertainty of a	0,188	
r^2	0,860		r^2	0,860	
Slope b forced trough origin	**0,991**				
Uncertainty of b (forced)	0,0132				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	0,96	µg/m³	**Calibration**	**0,854y + 1,187**	
Uncertainty of calibration (forced)	0,39	µg/m³	**u(calibration)**	**0,962**	µg/m³
Random term	0,81	µg/m³	Random term	1,06	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	3,74	µg/m³	Bias at LV	-0,29	µg/m³
Combined uncertainty	3,82	µg/m³	Combined uncertainty	1,10	µg/m³
Expanded relative uncertainty	**25,5%**	**fail**	**Expanded relative uncertainty**	**7,3%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	30	µg/m³	Limit value	30	µg/m³

A20. $PM_{2.5}$ equivalence tests for TEOM analyzers

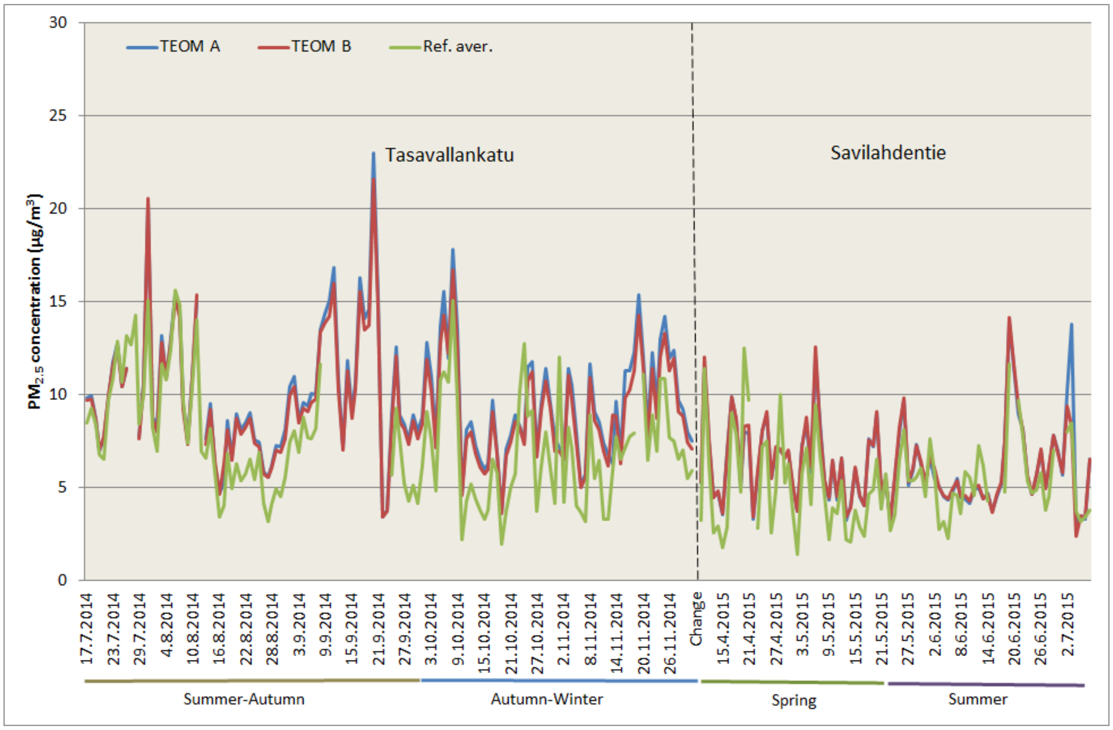

Figure A20.1: Time series of 24 h concentration values of TEOM and the RMs during the $PM_{2.5}$ equivalence campaigns in Kuopio.

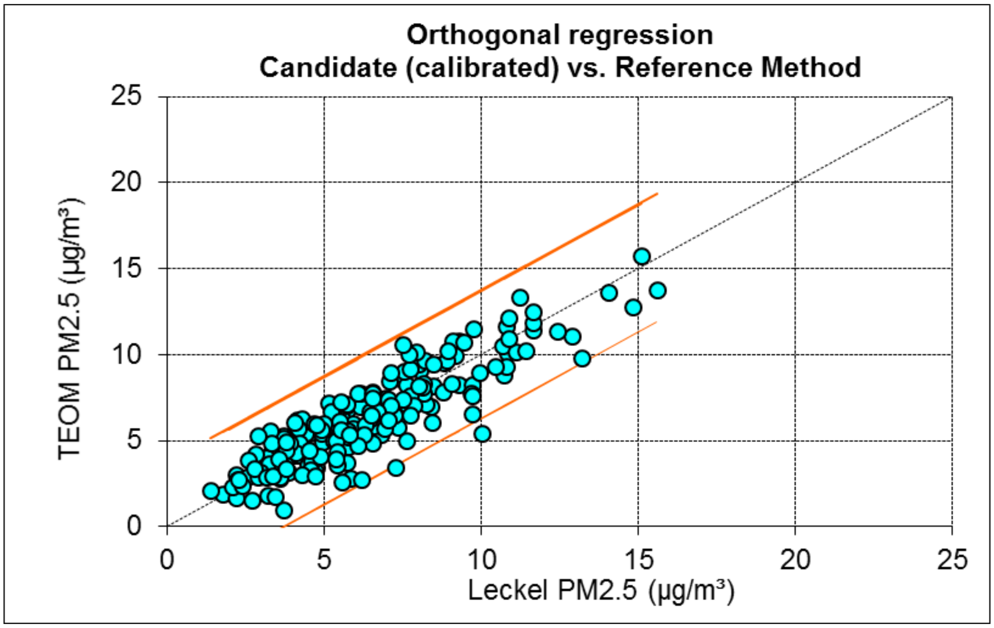

Figure A20.2: Scatter plot of TEOM versus the RMs: Calibrated data.

Table A20.1. Equivalence test results for TEOM against the RMs for $PM_{2.5}$, all data.

RAW DATA			RESULTS AFTER CALIBRATING		
Regression	**1,009y + -1,681**		N (Spring)	50	n
Regression (i=0)	**0,821y**		N (Summer)	73	n
N	196	n	N (Fall)	72	n
			N (Winter)	1	n
Outliers	8	n	Outliers	2	n
Outliers	4,1%	%	Outliers	1,0%	%
Mean CM	8,0	µg/m³	Mean CM	6,378	µg/m³
Mean RM	6,4	µg/m³	Mean RM	6,378	µg/m³
Number of RM > 0,6 * LV	0	n	Number of CM > 0,6 * LV	0	n
Number of RM > LV	0	n	Number of CM > LV	0	n
REGRESSION RESULTS (RAW)			**REGRESSION RESULTS (CALIBRATED)**		
Slope b	**0,99107**		**Slope b**	1,001	
Uncertainty of b	0,032		Uncertainty of b	0,033	
Intercept a	**1,66604**	**significant**	**Intercept a**	-0,007	
Uncertainty of a	0,226		Uncertainty of a	0,228	
r^2	0,794		r^2	0,794	
Slope b forced trough origin	**1,218**	**significant**			
Uncertainty of b (forced)	0,0163				
EQUIVALENCE TEST (RAW)			**EQUIVALENCE TEST (CALIBRATED)**		
Uncertainty of calibration	1,00	µg/m³	**Calibration**	**1,009y -1,681**	
Uncertainty of calibration (forced)	0,49	µg/m³	**u(calibration)**	**0,996**	µg/m³
Random term	0,85	µg/m³	Random term	1,32	µg/m³
Additional uncertainty (optional)	0,00	µg/m³	Additional uncertainty (optional)	0,00	µg/m³
Bias at LV	1,40	µg/m³	Bias at LV	0,03	µg/m³
Combined uncertainty	1,64	µg/m³	Combined uncertainty	1,32	µg/m³
Expanded relative uncertainty	**10,9%**	***pass***	**Expanded relative uncertainty**	**8,8%**	***pass***
Ref sampler uncertainty	1,00	µg/m³	Ref sampler uncertainty	1,00	µg/m³
Limit value	30	µg/m³	Limit value	30	µg/m³

A21: Calibration factors for CM for each $PM_{2.5}$ campaign

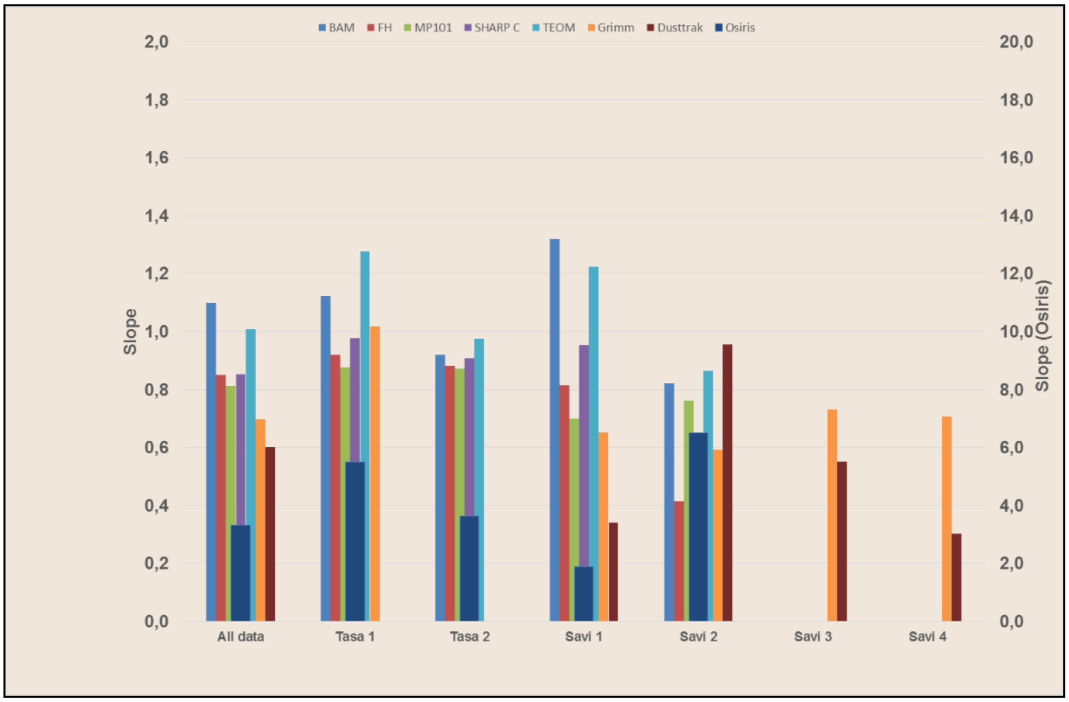

Figure A21.1: Slopes of the calibration equations for each CM at each campaign

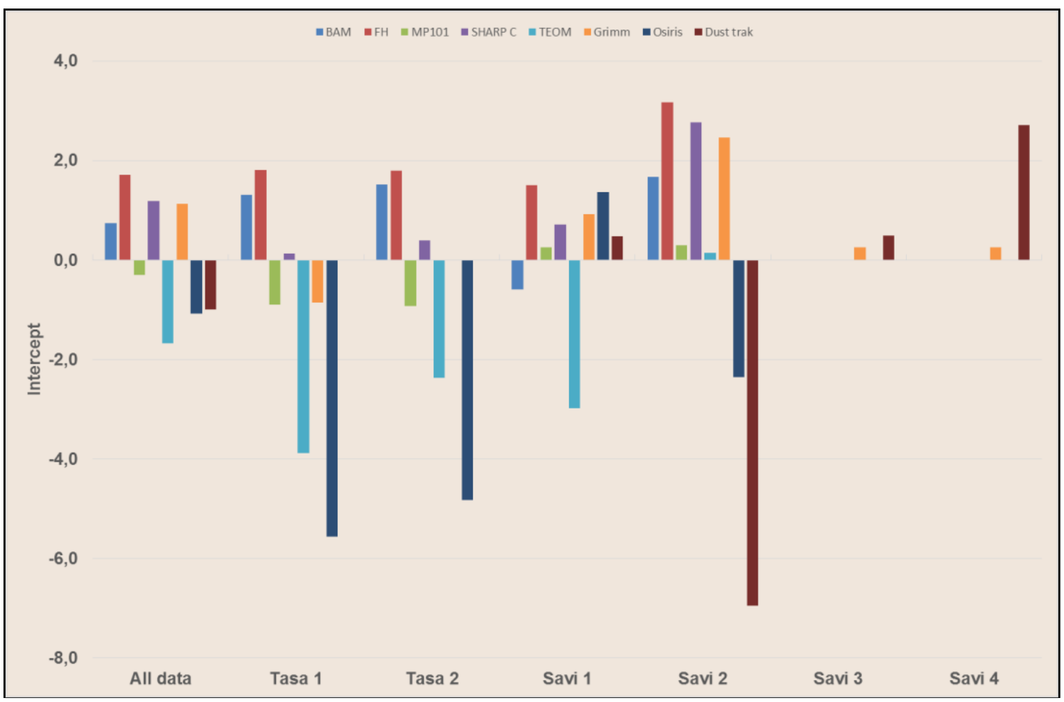

Figure A31.2: Intercepts for each CM for each campaign.

A22 Daily values of PM 10: Reference method, BAM, FH 62IR, Osiris

Date	Leckel R1 (09/0081) PM10	Leckel R2 (11/0070) PM10	BAM A-21 conc. PM10	BAM B-25 conc. PM10	FH-62 A-29 conc. PM10	FH-62 B-33 conc. PM10	Osiris A-38 PM10	Osiris B-42 PM10	Campaign
20.3.2014	19,65	18,99	20,50	18,25	14,20	14,46	11,06	12,57	Tasa 1
21.3.2014	7,89	7,90	7,57	5,94	7,22	6,03	5,96	6,85	Tasa 1
22.3.2014	33,63	34,82	41,01	40,14	21,44	22,10	22,19	26,43	Tasa 1
23.3.2014	16,92	17,34	17,92	17,30	13,85	12,80	10,75	11,49	Tasa 1
25.3.2014	30,76	31,43	39,71	37,11	24,73	23,54	23,30	26,03	Tasa 1
27.3.2014	31,04	29,63	35,41	33,25	23,80	23,43	23,57	23,43	Tasa 1
28.3.2014	49,38	51,79	47,68	48,19	33,96	33,88	39,89	40,16	Tasa 1
29.3.2014	23,84	23,96	30,25	27,68	18,21	17,46	15,35	18,14	Tasa 1
1.4.2014	33,47	31,42	41,71	38,07	32,16	28,26	25,81	32,83	Tasa 1
2.4.2014	36,66	37,94	50,49	48,31	34,39	29,46	23,76	31,71	Tasa 1
3.4.2014	20,61	20,19	27,46	24,13	13,44	14,69	12,33	15,12	Tasa 1
4.4.2014	37,80	37,49	43,79	41,21	25,96	26,17	28,31	34,08	Tasa 1
5.4.2014	18,62	18,27	24,31	22,84	16,58	15,86	10,17	12,87	Tasa 1
6.4.2014	29,25	28,80	34,51	32,51	23,71	21,84	22,14	26,14	Tasa 1
7.4.2014	35,65	34,55	40,73	36,40	27,87	28,71	30,18	35,55	Tasa 1
8.4.2014	41,30	39,79	51,10	47,15	30,67	30,54	32,79	37,05	Tasa 1
10.4.2014	47,88	48,59	59,78	62,02			29,79	34,84	Tasa 1
11.4.2014	7,79	7,46	7,66	7,04	9,57	8,80	3,72	4,26	Tasa 1
12.4.2014	17,26	18,00	19,70	19,69	12,33	11,03	10,52	11,81	Tasa 1
13.4.2014	8,45	9,12	6,52	5,79	7,34	7,10	6,15	6,83	Tasa 1
14.4.2014	19,74	21,05	24,36	23,46	16,78	16,00	15,27	18,47	Tasa 1
15.4.2014	15,22	14,46	27,03	20,52	20,60	11,57	15,10	20,63	Tasa 1
16.4.2014	57,39	56,41	71,98	69,37	36,98	46,28	44,97	53,39	Tasa 1
17.4.2014	40,45	40,42	46,75	49,97			28,02	33,89	Tasa 1
18.4.2014	19,22	18,66	18,31	18,57	14,04	13,43	11,21	13,06	Tasa 1
19.4.2014	25,29	25,09	27,31	27,93	20,07	19,84	16,22	20,31	Tasa 1
20.4.2014	19,72	19,28	19,39	18,39	11,86	12,78	17,27	17,90	Tasa 1
21.4.2014	29,68	30,03	35,77	34,03	28,19	26,64	26,81	29,38	Tasa 1
22.4.2014	20,58	19,32	26,62	25,49	10,97	11,39	14,40	19,79	Tasa 1
23.4.2014	31,63	31,04	42,03	39,66	25,46	26,29	25,35	31,87	Tasa 1
24.4.2014	34,09	32,42	40,95	38,31	25,97	25,66	23,83	31,28	Tasa 1
25.4.2014	24,39	24,47	25,89	24,52	17,32	18,85	19,33	21,60	Tasa 1
26.4.2014	19,21	19,55	19,35	18,73	19,19	18,03	13,42	14,13	Tasa 1
27.4.2014	27,18	27,24	33,38	31,01	22,76	25,08	24,19	28,71	Tasa 1
28.4.2014	39,83	40,04	46,79	45,67	26,95	28,97	32,95	38,12	Tasa 1
29.4.2014	17,76	17,88	23,98	21,47	13,01	13,04	13,07	17,52	Tasa 1
30.4.2014	20,44	20,31	21,23	19,48	16,96	16,43	10,75	17,13	Tasa 1
1.5.2014	9,07	8,93	11,64	9,51	10,35	9,25	6,57	8,34	Tasa 1
2.5.2014	13,94	13,49	16,36	14,99	10,02	10,65	12,36	16,33	Tasa 1
3.5.2014	11,28	11,25	12,74	11,24	10,81	9,38	7,24	8,95	Tasa 1
4.5.2014	13,68	14,56	16,41	16,29	9,68	8,95	10,18	13,41	Tasa 1
5.5.2014	14,94	15,93	17,86	15,73	12,97	13,12	9,71	13,76	Tasa 1
6.5.2014	14,37	13,84	17,00	15,99	12,69	11,91	9,45	12,27	Tasa 1
7.5.2014	18,99	18,51	24,04	22,43	14,80	15,70	13,48	15,86	Tasa 1
8.5.2014	23,23	22,29							Tasa 1
9.5.2014	10,98	11,40	10,91	10,54	10,79	10,75	7,87	8,39	Tasa 1
10.5.2014	14,96	14,76	16,20	15,19	10,87	11,46	8,89	9,63	Tasa 1
11.5.2014	8,51	8,47	9,38	7,38	6,99	7,31	6,24	7,71	Tasa 1
12.5.2014	19,95	20,53	22,25	20,99	18,43	17,93	15,65	17,01	Tasa 1
13.5.2014	4,27	4,01	2,99	1,87	0,56	1,91	2,72	3,07	Tasa 1
14.5.2014	9,89	8,64	12,26	9,28	10,15	7,84	7,85	10,55	Tasa 1
16.5.2014	16,01	15,79	15,24	15,37	18,94	17,56	10,92	12,07	Tasa 1
17.5.2014	14,02	13,55	12,88	13,37	12,59	13,20	8,29	8,99	Tasa 1
18.5.2014	26,11	26,13	26,67	25,79	21,49	22,36	19,69	21,27	Tasa 1
19.5.2014	48,11	46,54	50,51	49,01	36,25	37,90	37,55	40,17	Tasa 2
20.5.2014	37,66	35,46	37,77	35,88	25,49	26,84	22,80	26,30	Tasa 2
21.5.2014	31,58	30,14	34,10	30,72	23,94	23,32	16,26	18,91	Tasa 2
24.5.2014	37,02	35,13	30,37	30,23	25,77	26,94	17,88	19,56	Tasa 2
25.5.2014	17,34	16,47	14,82	13,82			14,27	15,63	Tasa 2
26.5.2014	6,13		5,14	3,64	4,52	3,81	4,33	5,89	Tasa 2
27.5.2014		8,48	10,63	8,58	9,57	8,69	6,73	9,32	Tasa 2
28.5.2014	8,03	9,11	9,49	8,11	7,59	8,14	6,18	7,69	Tasa 2
29.5.2014	7,34	8,02	7,14	6,39	8,04	7,75	6,89	7,89	Tasa 2
30.5.2014	14,14	14,56	16,00	15,12	14,81	14,23	10,97	13,78	Tasa 2
31.5.2014	11,35	11,83	10,87	10,86	11,31	11,09	7,62	8,65	Tasa 2
1.6.2014	7,56	7,39	8,00	5,89	5,67	7,23	4,14	5,44	Tasa 2
2.6.2014	9,28		12,25	9,88	14,11	13,27	6,54	8,34	Tasa 2
3.6.2014	25,64		28,42	26,43	18,75	19,56	18,29	20,54	Tasa 2
4.6.2014	49,33	49,22	56,25	53,24	47,11	46,46	45,76	49,67	Tasa 2
5.6.2014	42,72	42,66	47,38	44,87	34,41	36,65	36,38	40,45	Tasa 2
6.6.2014	33,62	33,15	35,46	33,71	28,29	29,71	32,66	35,45	Tasa 2
7.6.2014	17,65	17,33	18,24	17,73	6,09	9,48	12,60	13,77	Tasa 2
8.6.2014	12,67	12,75	14,50	11,63	11,87	11,23	7,59	9,04	Tasa 2
9.6.2014	6,69	6,66	7,75	7,00	1,84	2,41	5,79	7,81	Tasa 2
10.6.2014	14,14		15,52	14,77			11,27	13,59	Tasa 2
11.6.2014	20,26	20,60	22,76	20,88	16,11	19,45	15,30	17,83	Tasa 2
12.6.2014	16,51	16,14	18,74	16,11	13,16	13,05	13,28	16,57	Tasa 2
13.6.2014	8,26	8,98	9,60	7,85			6,54	8,04	Tasa 2
14.6.2014	5,76	6,09	5,38	5,26	10,78	9,25	2,86	3,61	Tasa 2
15.6.2014	8,81	8,86	9,75	8,24	6,87	7,29	6,68	8,15	Tasa 2
16.6.2014	4,65	4,71	3,38	3,25			3,90	5,09	Tasa 2
18.6.2014	5,74	5,54	8,33	5,87	6,94	6,48	4,88	6,73	Tasa 2
19.6.2014	6,09	6,03	6,12	4,70	5,56	5,74	3,83	4,88	Tasa 2
20.6.2014	4,89	4,91	3,58	3,21	4,49	4,98	1,80	2,12	Tasa 2
21.6.2014	5,17	5,20	3,59	2,83	2,40	2,98	3,05	3,39	Tasa 2
22.6.2014	7,58	7,62	8,42	6,50	9,64	9,02	5,50	6,83	Tasa 2
23.6.2014	8,47	8,69	10,01	7,51	8,87	5,93	5,73	7,69	Tasa 2
24.6.2014	10,31	10,42	9,62	9,80	4,53	7,48	6,80	8,51	Tasa 2
25.6.2014	15,76	15,89	15,80	14,01	5,93	9,60	11,26	13,43	Tasa 2
26.6.2014	15,00	15,30	17,25	16,46	14,42	13,43	12,34	14,01	Tasa 2
27.6.2014	14,67	14,46	13,24	11,99	9,42	10,85	7,79	9,67	Tasa 2
28.6.2014	10,25	10,42	9,83	9,16	7,14	7,33	7,23	8,53	Tasa 2
29.6.2014	8,72	8,79	8,75	8,00	6,27	7,18	5,27	6,43	Tasa 2
30.6.2014	7,28	7,44	8,43	6,93	6,24	5,86	4,92	6,82	Tasa 2
1.7.2014	6,14	6,19	8,28	6,03	6,13	5,78	5,78	7,75	Tasa 2
2.7.2014	19,29	19,33	17,94	18,41	13,99	13,25	13,93	16,15	Tasa 2
3.7.2014	14,52	14,75	13,45	12,50	13,61	13,12	12,09	14,64	Tasa 2
4.7.2014	11,79	11,93	12,69	10,57	9,07	10,72	8,85	10,54	Tasa 2
5.7.2014	10,36	10,51	10,83	9,38	10,23	9,02	6,79	7,73	Tasa 2
6.7.2014	15,85	16,74	17,14	15,19	14,74	14,70	11,84	14,45	Tasa 2
7.7.2014	21,03	21,33	24,30	21,50	18,50	17,88	16,78	19,37	Tasa 2
8.7.2014	16,66	16,25	18,46	16,79	14,53	13,54	9,43	10,94	Tasa 2
9.7.2014	11,76		12,85	10,40	6,21	6,19	7,79	9,20	Tasa 2
10.7.2014	12,80		13,68	11,84	8,20	11,62	10,29	12,29	Tasa 2
11.7.2014	11,28	11,43	10,99	10,20	10,17	10,43	8,06	9,23	Tasa 2
12.7.2014	12,92	13,13	12,92	11,58	8,40	9,35	7,72	8,45	Tasa 2
13.7.2014	17,43	17,90	18,83	17,07	15,84	16,33	10,21	11,55	Tasa 2

Date	Leckel R1 (09/0081) PM10	Leckel R2 (11/0070) PM10	BAM A-21 conc. PM10	BAM B-25 conc. PM10	FH-62 A-29 conc. PM10	FH-62 B-33 conc. PM10	Osiris A-38 PM10	Osiris B-42 PM10	Campaign
5.12.2014	3,09	2,95	1,00	1,00		8,44	4,84	5,56	Savi 1
6.12.2014	3,43	3,24	1,76	0,38		1,64	2,99	3,24	Savi 1
7.12.2014	4,90	4,90	3,62	2,62		7,30	3,15	3,34	Savi 1
8.12.2014	5,24	5,16	3,63	3,25		12,52	4,56	4,45	Savi 1
9.12.2014	7,33	7,40	6,26	6,38	2,14	6,07	2,89	2,93	Savi 1
10.12.2014	10,14	9,55	11,12	10,49	5,64	6,88	3,30	3,36	Savi 1
11.12.2014	9,58	9,06	8,00	7,00	8,52	8,37	3,54	3,56	Savi 1
12.12.2014	10,36	10,25	9,00	8,87	9,32	8,91	3,97	3,97	Savi 1
13.12.2014	5,15	4,97	4,37	3,37	3,38	3,96	3,43	3,50	Savi 1
14.12.2014	5,87	6,21	5,25	3,75	7,03	6,44	3,69	3,74	Savi 1
15.12.2014	6,46	6,47	5,37	4,62	4,73	5,14	4,54	4,59	Savi 1
16.12.2014	6,33	6,38	4,65	4,15	6,93	6,93	4,36	4,33	Savi 1
17.12.2014	7,32	7,07	5,38	5,04	7,35	4,69	5,16	3,83	Savi 1
25.12.2014	10,63	11,43	6,62	6,70	15,71	11,01			Savi 1
26.12.2014	3,63	4,01	1,96	0,46	1,98	2,50			Savi 1
27.12.2014	10,20	9,75	8,50	7,97	1,46	2,38			Savi 1
28.12.2014	30,73	29,70	26,43	27,14					Savi 1
29.12.2014	30,85	29,57	27,04	28,15	18,76	23,07	13,27	13,96	Savi 1
30.12.2014	2,46	3,63	3,95	2,45			1,93	1,72	Savi 1
31.12.2014	4,00	3,97	2,54	1,37	4,63	5,58	2,80	3,01	Savi 1
1.1.2015	2,53	2,91	1,04	0,38	2,23	3,03	2,10	2,36	Savi 1
2.1.2015	1,55	1,70	-0,84	-0,71			1,65	1,65	Savi 1
3.1.2015	3,46	3,97	1,30	0,21			2,24	1,25	Savi 1
4.1.2015	9,35	9,25	9,30	8,14	2,97	2,11	5,97	6,36	Savi 1
5.1.2015	10,07	9,55	9,20	8,91	6,90	5,02	6,57	7,06	Savi 1
6.1.2015	43,06	40,07	32,29	32,62	27,90	25,65	24,24	26,61	Savi 1
7.1.2015	5,50	6,00	5,00	4,21	13,73	10,86	3,73	2,32	Savi 1
9.1.2015	6,91		5,67	4,51	2,91	3,39	4,60	2,87	Savi 1
10.1.2015	9,24		9,26	7,50			4,15	3,46	Savi 1
11.1.2015	13,29		16,10	13,49	15,46	13,85			Savi 1
12.1.2015	33,02		32,69	30,73	24,14	21,93	15,77	16,67	Savi 1
13.1.2015	26,97		26,38	24,25	24,28	22,72	13,24	12,92	Savi 1
14.1.2015	5,76		4,91	4,32	14,49	10,46	3,75	3,86	Savi 1
15.1.2015	5,27		3,54	2,58	3,22	3,57	4,52	4,22	Savi 1
16.1.2015	5,82		4,00	3,05	7,22	6,39	5,30	5,96	Savi 1
17.1.2015	8,80		7,12	5,99	7,50	7,85	8,06	8,84	Savi 1
18.1.2015			1,80	0,85			2,27	2,63	Savi 1
19.1.2015	29,37		28,67	27,18			16,81	18,44	Savi 1
20.1.2015	57,97						32,11	34,95	Savi 1
21.1.2015	37,80		39,28	38,95	30,45	27,65	18,08	19,67	Savi 1
22.1.2015	65,57		65,35	63,48	50,69	45,98	32,67	36,02	Savi 1
23.1.2015	23,68		26,00	25,20	29,81	25,25	10,27	11,09	Savi 1
24.1.2015	9,14		9,43	8,35	13,78	11,77	2,76	3,14	Savi 1
25.1.2015	7,46		6,09	5,34	7,35	7,74	1,59	1,72	Savi 1
26.1.2015	4,98		4,41	3,50	3,88	4,35	2,36	2,07	Savi 1
27.1.2015	3,74		2,41	1,37			2,51	3,33	Savi 1
28.1.2015	3,59		1,75	0,80	6,40	4,68	2,13	2,12	Savi 1
29.1.2015	11,81		11,17	10,09	10,77	9,78	4,74	5,16	Savi 1
30.1.2015	10,31		10,37	9,20	8,36	7,53	3,38	3,92	Savi 1
31.1.2015	6,93		5,75	5,08	5,71	6,08	3,41	1,42	Savi 1
1.2.2015	4,99		4,55	2,80	5,46	5,05	2,23	1,91	Savi 1
2.2.2015	7,66		7,67	6,38	8,62	7,69	5,09	5,33	Savi 1
3.2.2015	13,04		11,55	10,38	14,35	12,62	3,14	3,49	Savi 1
4.2.2015	12,83		11,92	11,46	6,64	7,26	4,55	5,19	Savi 1
5.2.2015	7,71		7,48	7,15	9,62	8,27	1,97	2,25	Savi 1
6.2.2015	3,63		1,83	1,00	4,21	2,69	2,51	2,82	Savi 2
7.2.2015	3,62		2,46	1,92	0,66	1,63	3,62	3,79	Savi 2
8.2.2015	38,06		33,54	32,22			22,60	24,72	Savi 2
9.2.2015	15,20		16,28	15,56			7,68	8,37	Savi 2
10.2.2015	4,36		2,59	1,76	6,91	6,44	2,72	3,17	Savi 2
11.2.2015	5,97		4,99	3,83			3,07	3,50	Savi 2
12.2.2015	34,92		43,59	41,02	18,59	18,97	20,69	23,06	Savi 2
13.2.2015	67,20		76,45	73,02	55,80	51,52	40,52	44,95	Savi 2
14.2.2015	4,23		2,52	1,73			2,02	2,41	Savi 2
15.2.2015	55,01		55,29	52,94	37,54	31,60	27,37	34,37	Savi 2
16.2.2015	31,32		35,14	32,77	29,07	26,21	15,95	19,79	Savi 2
17.2.2015	16,46		16,98	15,69	21,26	17,80	6,56	7,52	Savi 2
18.2.2015	6,15		4,96	4,16	3,09	3,56	5,57	6,25	Savi 2
19.2.2015	6,48		4,88	3,83	9,76	7,87	3,74	4,02	Savi 2
20.2.2015	5,27		3,33	2,42	3,53	3,90	2,78	2,92	Savi 2
21.2.2015	9,14		7,31	5,14	4,34	3,90	3,21	3,12	Savi 2
22.2.2015	7,87		6,40	5,89	6,80	5,32	2,76	3,10	Savi 2
23.2.2015	8,65		7,01	5,48	7,66	5,98	3,91	4,02	Savi 2
24.2.2015	9,88		8,57	8,66	11,26	9,14	5,09	5,81	Savi 2
25.2.2015	14,71		10,96	10,42	12,19	10,46	8,49	9,29	Savi 2
5.3.2015	5,08		2,88	2,67			2,87	2,97	Savi 2
6.3.2015	4,01		2,41	2,08	4,14	3,23	3,52	3,56	Savi 2
7.3.2015	6,33		4,63	3,92	8,13	6,00	3,73	4,04	Savi 2
8.3.2015	6,31		5,18	4,34	5,26	4,95	3,55	3,77	Savi 2
9.3.2015	80,48		97,37	92,14	53,63	48,57	56,98	56,49	Savi 2
10.3.2015	13,83		17,69	16,12	15,22	13,12	8,39	8,15	Savi 2
11.3.2015	89,54		105,07	106,11	69,59	63,90	71,40	65,86	Savi 2
12.3.2015	196,14				165,96	148,28	144,53	134,44	Savi 2
13.3.2015	274,44		280,41	275,55	215,00	195,26	203,22	183,93	Savi 2
14.3.2015	103,87		101,48	100,94	87,47	77,89	75,48	67,89	Savi 2
15.3.2015	274,83		290,23	286,94	223,83	205,35	204,33	190,94	Savi 2
16.3.2015	290,62		310,36	305,48	236,36	215,35	213,64	196,32	Savi 2
17.3.2015	240,63		254,73	250,79	197,16	180,71	174,61	162,30	Savi 2
18.3.2015	150,62		162,06	157,10	126,13	116,67	109,20	104,53	Savi 2
19.3.2015	21,44		30,33	27,79	16,24	15,94	10,01	14,08	Savi 2
20.3.2015	26,86		37,34	35,36	9,65	9,97	12,63	12,78	Savi 2
21.3.2015	27,73		37,06	35,61	19,72	16,57	14,41	13,61	Savi 2
22.3.2015	20,24		28,01	26,06	25,00	21,41	18,70	16,14	Savi 2
26.3.2015	39,78		52,10	49,06	34,27	32,05	27,35	26,08	Savi 2
27.3.2015	25,60		32,93	31,13	28,27	24,69	12,70	12,34	Savi 2
28.3.2015	24,10		23,01	21,80	22,44	19,66	4,76	4,93	Savi 2
29.3.2015	24,58		23,77	22,89	19,28	18,43	7,98	8,50	Savi 2
30.3.2015	12,92		12,56	11,14	12,04	10,60	10,50	10,61	Savi 2
31.3.2015	4,22		3,17	2,42	5,51	5,28	2,00	1,89	Savi 2
1.4.2015	25,30		26,13	24,50	21,26	19,37	21,50	20,53	Savi 2
2.4.2015	6,42		5,82	5,32	5,45	4,98	4,48	4,27	Savi 2
3.4.2015	14,91		15,46	15,20	11,91	10,84	11,01	9,82	Savi 2
4.4.2015	49,64		52,69	50,74	34,74	33,49	36,56	34,48	Savi 2
5.4.2015	59,26		64,76	61,71	43,50	40,59	52,14	46,40	Savi 2
6.4.2015	53,73		66,64	62,14	43,50	39,07	42,06	44,81	Savi 2
7.4.2015	86,38				62,33	58,32	64,32	62,83	Savi 2
8.4.2015	56,75				50,63	44,58	45,72	32,76	Savi 2

A23 Daily values of PM 10: Reference method, TEOM, SHARP, MP 101

Date	Leckel R1 (09/0081) PM10	Leckel R2 (11/0070) PM10	TEOM A-9 PM10	TEOM B-15 PM10	SHARP A-21 c-dust PM10	SHARP B-25 c-dust PM10	MP101 A-29 1 h mass conc. PM10	MP101 B-33 1 h mass conc. PM10	Campaign
20.3.2014	19,65	18,99	21,01	21,12		15,39	14,73	18,79	Tasa 1
21.3.2014	7,89	7,90	11,35	10,94	8,11	4,67	9,15	7,84	Tasa 1
22.3.2014	33,63	34,82	50,92	49,35	24,84	24,95	33,96	36,27	Tasa 1
23.3.2014	16,92	17,34	25,69	24,97	13,63	11,08	15,86	17,69	Tasa 1
24.3.2014	26,04	27,11	35,55	35,27	22,40	28,18	28,34	29,54	Tasa 1
25.3.2014	30,76	31,43	41,31	38,28	19,94	23,22	34,60	33,75	Tasa 1
27.3.2014	31,04	29,63	39,87	38,04	21,00	23,07	32,94	35,83	Tasa 1
28.3.2014	49,38	51,79	61,51	57,91	30,40	36,60	48,67	51,28	Tasa 1
29.3.2014	23,84	23,96	32,94	31,62	25,11	23,08	27,30	28,09	Tasa 1
30.3.2014	17,46	17,61	22,71	21,85	8,23	11,25	18,91	19,48	Tasa 1
31.3.2014	32,40	31,19	41,89	39,59			36,03	37,57	Tasa 1
1.4.2014	33,47	31,42	45,68	44,01			35,19	37,86	Tasa 1
2.4.2014	36,66	37,94	56,06	54,52	19,93	21,76	38,52	40,93	Tasa 1
3.4.2014	20,61	20,19	28,49	27,85			24,24	26,60	Tasa 1
4.4.2014	37,80	37,49			21,79	25,04	38,46	40,63	Tasa 1
5.4.2014	18,62	18,27	25,49	26,42	18,98	16,27	20,14	20,06	Tasa 1
6.4.2014	29,25	28,80	35,74	33,81	19,85	18,41	31,49	31,83	Tasa 1
7.4.2014	35,65	34,55	46,69	43,07	30,36	29,30	41,12	40,57	Tasa 1
8.4.2014	41,30	39,79	47,48	45,97	33,54	30,59	44,91	45,13	Tasa 1
9.4.2014	43,01	43,28	60,27	57,55			50,81	49,26	Tasa 1
10.4.2014	47,88	48,59	77,75	75,71	39,27	33,46	50,98	50,45	Tasa 1
11.4.2014	7,79	7,46	11,81	11,22	13,49	10,49	9,52	23,25	Tasa 1
12.4.2014	17,26	18,00	27,14	26,58	12,57	10,58			Tasa 1
13.4.2014	8,45	9,12	12,21	11,71	7,50	9,96	6,54	6,68	Tasa 1
14.4.2014	19,74	21,05	31,61	31,61	15,74	13,74	23,76	21,64	Tasa 1
15.4.2014	15,22	14,46	17,59	20,98	10,21	11,21	21,93	20,81	Tasa 1
16.4.2014	57,39	56,41			37,73	37,92	59,67	62,50	Tasa 1
17.4.2014	40,45	40,42	63,00	62,72	32,20	28,95	46,16	46,30	Tasa 1
18.4.2014	19,22	18,66	24,64	23,52	15,45	15,27	20,52	18,47	Tasa 1
19.4.2014	25,29	25,09	35,61	35,23	18,89	16,89	28,46	28,63	Tasa 1
20.4.2014	19,72	19,28	26,46	24,90	14,63	13,82	21,98	21,13	Tasa 1
21.4.2014	29,68	30,03	39,26	39,29	24,44	24,43	32,06	31,69	Tasa 1
22.4.2014	20,58	19,32	30,97	28,96	14,83	14,18	27,30	25,64	Tasa 1
23.4.2014	31,63	31,04	44,66	41,71	22,32	23,82	38,85	37,91	Tasa 1
24.4.2014	34,09	32,42	46,03	43,67	25,96	23,86	38,24	38,00	Tasa 1
25.4.2014	24,39	24,47	32,72	30,50	22,43	21,52	25,40	26,92	Tasa 1
26.4.2014	19,21	19,55	24,37	23,66	20,79	20,68	18,50	20,48	Tasa 1
27.4.2014	27,18	27,24	34,95	34,24	18,87	19,64	29,28	30,65	Tasa 1
28.4.2014	39,83	40,04	51,01	47,71	28,29	29,62	44,80	45,01	Tasa 1
29.4.2014	17,76	17,88	27,97	26,01	17,16	13,69	17,84	20,85	Tasa 1
30.4.2014	20,44	20,31	25,79	25,48	17,98	17,34	22,60	21,97	Tasa 1
1.5.2014	9,07	8,93	14,14	13,34	9,87	8,70	9,28	10,32	Tasa 1
2.5.2014	13,94	13,49	20,95	20,09	11,52	10,15	16,75	15,98	Tasa 1
3.5.2014	11,28	11,25	16,90	15,61	11,57	11,41	11,57	11,88	Tasa 1
4.5.2014	13,68	14,56	22,43	21,49	8,73	7,54	13,93	15,31	Tasa 1
5.5.2014	14,94	15,93	23,47	22,59	14,93	12,90	19,48	23,29	Tasa 1
6.5.2014	14,37	13,84	20,94	19,36	11,86	12,35	17,12	15,58	Tasa 1
7.5.2014	18,99	18,51	28,54	26,75	14,43	14,67	19,78	18,59	Tasa 1
8.5.2014	23,23	22,29							Tasa 1
9.5.2014	10,98	11,40	15,32	14,68	13,96	13,48	11,87	11,76	Tasa 1
10.5.2014	14,96	14,76	20,46	19,51	12,46	12,00	15,32	13,55	Tasa 1
11.5.2014	8,51	8,47	12,27	11,79	7,91	8,11	10,35	9,83	Tasa 2
12.5.2014	19,95	20,53	26,57	25,69	17,36	18,60	21,64	20,70	Tasa 2
13.5.2014	4,27	4,01	5,28	5,09	6,77	5,59	6,25	4,59	Tasa 2
14.5.2014	9,89	8,64	14,17	13,54	6,00	5,34	13,74	13,04	Tasa 2
15.5.2014	21,30	19,20	29,80	27,50	12,43	13,71	20,09	19,33	Tasa 2
16.5.2014	16,01	15,79	23,70	22,58	14,05	12,97	16,87	17,94	Tasa 2
17.5.2014	14,02	13,55	18,05	17,80	10,00	11,31	11,65	11,85	Tasa 2
18.5.2014	26,11	26,13	33,44	32,68	19,76	22,27	27,14	26,09	Tasa 2
19.5.2014	48,11	46,54			38,15	41,38	43,94	43,22	Tasa 2
20.5.2014	37,66	35,46	40,34	41,74	31,39	32,59	37,45	36,99	Tasa 2
21.5.2014	31,58	30,14	31,92	31,27	30,96	32,19	32,28	30,88	Tasa 2
24.5.2014	37,02	35,13	35,81	35,18	26,22	28,65	29,79	28,64	Tasa 2
25.5.2014	17,34	16,47	15,63	15,08	16,53	16,33	17,53	20,03	Tasa 2
2.6.2014	9,28		11,26	10,99	7,19	7,50	8,78	8,24	Tasa 2
3.6.2014	25,64		28,66	27,60	21,81	24,98	22,69	22,53	Tasa 2
4.6.2014	49,33	49,22	60,51	59,14	41,38	42,10	51,32	49,24	Tasa 2
5.6.2014	42,72	42,66	50,49	49,40	33,68	36,39	43,20	40,78	Tasa 2
6.6.2014	33,62	33,15	42,94	42,02	31,25	32,63	36,90	34,50	Tasa 2
7.6.2014	17,65	17,33	21,78	20,81	19,90	21,27	20,23	21,44	Tasa 2
8.6.2014	12,67	12,75	12,83	12,42	12,05	12,39	11,60	11,04	Tasa 2
9.6.2014	6,69	6,66	7,06	7,05	6,32	5,79	7,78	7,96	Tasa 2
11.6.2014	20,26	20,60	24,78	23,92	17,09	17,40	16,13	16,12	Tasa 2
12.6.2014	16,51	16,14	20,14	19,27	14,53	14,42	16,56	16,10	Tasa 2
13.6.2014	8,26	8,98	11,00	10,53	9,44	9,23	11,15	11,34	Tasa 2
14.6.2014	5,76	6,09			4,97	6,35	5,91	5,04	Tasa 2
15.6.2014	8,81	8,86			5,86	5,91	6,51	7,69	Tasa 2
16.6.2014	4,65	4,71	6,29	5,65	5,25	4,92	5,31	5,19	Tasa 2
18.6.2014	5,74	5,54	9,65	9,06	5,24	5,79	6,56	6,16	Tasa 2
19.6.2014	6,09	6,03	8,04	7,85	5,87	7,72	6,15	6,70	Tasa 2
20.6.2014	4,89	4,91	6,98	6,68	5,05	5,23	5,86	4,48	Tasa 2
21.6.2014	5,17	5,20	9,03	8,77	4,46	4,37	6,07	6,65	Tasa 2
22.6.2014	7,58	7,62	10,84	10,53	6,15	6,71	8,21	8,04	Tasa 2
23.6.2014	8,47	8,69	12,90	12,47	7,89	9,19	8,72	8,86	Tasa 2
24.6.2014	10,31	10,42	13,49	12,59	8,97	11,05	9,75	8,79	Tasa 2
25.6.2014	15,76	15,89	21,21	20,05	10,41	11,33	15,64	14,51	Tasa 2
26.6.2014	15,00	15,30	21,65	20,97	13,72	13,73	17,00	15,85	Tasa 2
27.6.2014	14,67	14,46	18,66	17,45	12,11	12,73	14,21	13,98	Tasa 2
28.6.2014	10,25	10,42	15,60	14,49	9,07	8,82	10,08	9,65	Tasa 2
29.6.2014	8,72	8,79	11,21	10,60	8,15	8,47	8,19	8,46	Tasa 2
30.6.2014	7,28	7,44	8,62	8,43	7,46	8,70	5,99	7,72	Tasa 2
1.7.2014	6,14	6,19	8,52	8,35	6,24	5,95	7,14	7,83	Tasa 2
2.7.2014	19,29	19,33			12,48	12,69	18,86	17,39	Tasa 2
3.7.2014	14,52	14,75	19,58	18,94	13,78	14,56	14,99	15,41	Tasa 2
4.7.2014	11,79	11,93	15,02	14,74	12,81	13,21	13,21	14,07	Tasa 2
5.7.2014	10,36	10,51	13,03	12,80	10,10	10,13	10,36	11,59	Tasa 2
6.7.2014	15,85	16,74	21,07	20,46	11,88	12,58	15,79	15,50	Tasa 2
7.7.2014	21,03	21,33	27,18	26,05	19,09	19,47	21,42	20,85	Tasa 2
8.7.2014	16,66	16,25	19,36	18,82	16,25	16,88	16,09	15,98	Tasa 2
11.7.2014	11,28	11,43	13,71	13,64	9,35	9,53	10,46	10,88	Tasa 2
12.7.2014	12,92	13,13	16,01	15,24	10,73	11,61	12,27	11,50	Tasa 2
13.7.2014	17,43	17,90	20,75	20,16	16,07	17,61	17,89	16,61	Tasa 2
14.7.2014	26,26	25,31	29,43	28,53	25,84	24,72	27,18	26,88	Tasa 2

Date	Leckel R1 (09/0081) PM10	Leckel R2 (11/0070) PM10	TEOM A-9 PM10	TEOM B-15 PM10	SHARP A-21 c-dust PM10	SHARP B-25 c-dust PM10	MP101 A-29 1 h mass conc. PM10	MP101 B-33 1 h mass conc. PM10	Campaign
5.12.2014	3,09	2,95	4,64	4,30	3,95	4,05			Savi 1
6.12.2014	3,43	3,24	5,90	5,63	3,91	3,24			Savi 1
7.12.2014	4,90	4,90	7,61	7,20	4,06	3,99			Savi 1
8.12.2014	5,24	5,16	8,87	8,40	5,18	7,03			Savi 1
9.12.2014	7,33	7,40	10,58	10,95	6,15	6,26			Savi 1
10.12.2014	10,14	9,55	14,06	14,45	9,31	9,10			Savi 1
11.12.2014	9,58	9,06	11,90	12,11	10,21	9,93			Savi 1
12.12.2014	10,36	10,25	11,52	11,80	11,26	10,80			Savi 1
13.12.2014	5,15	4,97	8,78	8,90	5,65	5,13			Savi 1
14.12.2014	5,87	6,21	9,41	9,53	6,07	5,91			Savi 1
15.12.2014	6,46	6,47	9,14	9,14	7,07	6,29			Savi 1
16.12.2014	6,33	6,38	9,41	9,57	7,52	6,09			Savi 1
17.12.2014	7,32	7,07	7,91	9,18	8,22	9,44	11,01	5,54	Savi 1
30.12.2014	2,46	3,63	5,01	4,90	6,45	3,58	4,42	5,15	Savi 1
31.12.2014	4,00	3,97	6,43	6,37	5,22	4,58	3,81	4,07	Savi 1
1.1.2015	2,53	2,91	3,99	3,96	3,99	3,39	3,68	1,89	Savi 1
2.1.2015	1,55	1,70	2,71	2,76	2,45	1,70	2,23	2,17	Savi 1
3.1.2015	3,46	3,97			4,27	3,52	7,24	8,00	Savi 1
4.1.2015	9,35	9,25			8,38	7,41	13,16	13,97	Savi 1
5.1.2015	10,07	9,55	11,69	13,26	2,61	8,19	11,19	12,75	Savi 1
6.1.2015	43,06	40,07	35,13	35,07	23,52	20,70	42,57	39,04	Savi 1
7.1.2015	5,50	6,00	7,36	7,29	10,67	6,17	3,86	3,69	Savi 1
9.1.2015	6,91		9,24	9,04	6,44	7,56	7,31	7,85	Savi 1
10.1.2015	9,24		11,58	11,39	7,21	7,63	7,51	9,57	Savi 1
11.1.2015	13,29		20,13	19,57	11,04	12,62	17,59	18,73	Savi 1
12.1.2015	33,02		35,46	34,89	21,87	21,50	34,45	35,08	Savi 1
13.1.2015	26,97		32,53	31,67	20,28	19,88	30,48	32,81	Savi 1
14.1.2015	5,76		9,91	9,96	7,51	6,69	8,15	7,66	Savi 1
15.1.2015	5,27		7,43	7,28	6,00	5,29	6,43	4,67	Savi 1
16.1.2015	5,82		8,24	8,38	5,73	4,99	4,76	6,02	Savi 1
17.1.2015	8,80		12,00	11,87	9,12	8,22	9,57	9,08	Savi 1
18.1.2015	3,72		8,92	8,29	3,95	4,31	8,34	7,50	Savi 1
19.1.2015	29,37		33,12	30,56	19,43	21,21	26,34	23,87	Savi 1
20.1.2015	57,97		53,04	52,33					Savi 1
21.1.2015	37,80		42,82	39,00			38,99	37,99	Savi 1
22.1.2015	65,57		69,18	63,75			70,52	67,98	Savi 1
23.1.2015	23,68		28,64	26,81	21,79	23,26	25,01	26,32	Savi 1
24.1.2015	9,14		13,21	12,90	8,52	9,29	11,06	12,10	Savi 1
25.1.2015	7,46		9,95	9,55	7,35	8,20	7,93	6,89	Savi 1
26.1.2015	4,98		6,82	6,80	4,79	4,91	4,82	5,04	Savi 1
27.1.2015	3,74		5,40	5,29	3,89	4,10	3,79	3,35	Savi 1
28.1.2015	3,59		5,96	6,03	3,90	4,26	2,78	3,17	Savi 1
29.1.2015	11,81		15,97	15,56	12,26	13,48	12,10	12,84	Savi 1
30.1.2015	10,31		13,94	13,41	10,40	10,28	11,84	12,18	Savi 1
31.1.2015	6,93		8,00	8,03	7,17	7,43	5,77	5,72	Savi 1
1.2.2015	4,99		8,53	8,33	5,55	6,10	6,15	6,33	Savi 1
2.2.2015	7,66		13,35	13,02	8,44	8,57	10,70	12,70	Savi 1
3.2.2015	13,04				12,72	12,04	14,16	15,37	Savi 1
4.2.2015	12,83				10,99	10,12	13,74	14,75	Savi 1
5.2.2015	7,71		6,40	7,69	7,74	7,31	6,97	6,45	Savi 1
6.2.2015	3,63		4,40	4,96	3,25	3,43	4,56	4,88	Savi 2
7.2.2015	3,62		5,87	6,38	2,82	3,27	3,60	4,42	Savi 2
8.2.2015	38,06		43,40	42,01			35,04	35,63	Savi 2
9.2.2015	15,20		21,11	20,64	12,96	13,59	17,74	19,00	Savi 2
10.2.2015	4,36		8,46	8,41	4,47	3,87	4,71	4,51	Savi 2
11.2.2015	5,97		9,12	9,30	5,45	5,40	5,68	6,34	Savi 2
12.2.2015	34,92				20,31	19,24	39,57	41,00	Savi 2
13.2.2015	67,20				55,13	54,56	82,46	83,44	Savi 2
14.2.2015	4,23				7,01	6,15	7,73	9,51	Savi 2
15.2.2015	55,01				33,84	37,99	60,43	62,19	Savi 2
16.2.2015	31,32		40,55	37,57	22,22	22,70	30,09	31,72	Savi 2
17.2.2015	16,46		19,14	18,58	16,74	17,50	12,49	13,26	Savi 2
18.2.2015	6,15		8,41	8,23	5,19	4,74	5,37	6,87	Savi 2
19.2.2015	6,48				5,26	5,08	3,75	6,49	Savi 2
20.2.2015	5,27				5,47	5,02	5,32	4,69	Savi 2
21.2.2015	9,14				8,79	9,09	6,92	7,83	Savi 2
22.2.2015	7,87				6,93	6,80	9,74	11,88	Savi 2
23.2.2015	8,65		10,81	11,09	8,90	8,68	6,62	9,23	Savi 2
24.2.2015	9,88		13,61	13,30	9,27	9,08	10,91	14,48	Savi 2
25.2.2015	14,71		15,75	15,11	12,53	12,08	12,53	16,23	Savi 2
5.3.2015	5,08		7,11	6,98	4,65	4,71	5,10	5,40	Savi 2
6.3.2015	4,01		6,64	6,57	3,78	3,96	5,17	3,08	Savi 2
7.3.2015	6,33		7,06	7,11	5,18	5,78	3,03	5,36	Savi 2
8.3.2015	6,31		7,84	9,33	5,16	5,14	6,52	7,32	Savi 2
9.3.2015	80,48		113,55	112,57	48,26	47,27	89,82	104,47	Savi 2
10.3.2015	13,83		21,64	20,95	20,03	17,83	19,97	24,47	Savi 2
11.3.2015	89,54		110,96	104,64	50,11	55,81	103,74	109,04	Savi 2
12.3.2015	196,14		236,48	223,79			234,18	245,93	Savi 2
13.3.2015	274,44		321,92	308,74	201,29	189,50	347,43	353,03	Savi 2
14.3.2015	103,87		119,53	112,65	87,78	86,18	122,66	130,37	Savi 2
15.3.2015	274,83		317,99	304,57	194,93	188,94	323,50	338,20	Savi 2
16.3.2015	290,62		341,08	328,89	224,86	212,45	358,72	368,43	Savi 2
17.3.2015	240,63		279,76	270,99	181,60	174,53	286,24	298,84	Savi 2
18.3.2015	150,62		180,83	179,49			176,82	195,83	Savi 2
19.3.2015	21,44		25,53	26,61	24,85	24,21	22,80	25,61	Savi 2
20.3.2015	26,86		47,23	49,08	18,55	15,19	28,30	32,76	Savi 2
21.3.2015	27,73		47,74	49,78	23,24	17,86	29,97	35,19	Savi 2
22.3.2015	20,24		27,50	27,86	16,03	15,42	20,59	22,65	Savi 2
26.3.2015	39,78		54,27	54,05	34,02	33,45	44,88	50,79	Savi 2
27.3.2015	25,60		35,76	35,72	26,75	26,54	56,12	30,36	Savi 2
28.3.2015	24,10		25,13	25,08	24,29	24,01	22,05	24,22	Savi 2
29.3.2015	24,58		26,32	26,39	21,39	22,28	19,98	22,77	Savi 2
30.3.2015	12,92		14,31	14,50	13,99	13,26	10,89	13,25	Savi 2
31.3.2015	4,22		8,64	7,26	5,01	4,19	5,74	5,94	Savi 2
1.4.2015	25,30		30,06	30,95	19,62	18,77	23,80	28,13	Savi 2
2.4.2015	6,42		9,74	9,83	8,63	9,07	7,16	7,55	Savi 2
3.4.2015	14,91		19,72	20,13	10,38	10,48	15,48	17,51	Savi 2
4.4.2015	49,64		64,19	66,43	35,70	33,20	54,42	58,47	Savi 2
5.4.2015	59,26		70,11	72,17	44,07	42,09	62,09	71,92	Savi 2
6.4.2015	53,73		69,64	73,41	37,04	34,97	52,28	60,27	Savi 2
7.4.2015	86,38				60,96	55,64	96,66	108,53	Savi 2
8.4.2015	56,75								Savi 2

A24 Daily values of PM 10: Reference method, Grimm 180

Date	Leckel R1 (09/0081) PM10	Leckel R2 (11/0070) PM10	Grimm 180 B-5 PM10	Grimm 180 C-1 PM10	Grimm 180 B + C average PM10	Campaign
19.5.2014	48,11	46,54				Tasa 2
20.5.2014	37,66	35,46				Tasa 2
21.5.2014	31,58	30,14	38,62	25,50	32,06	Tasa 2
24.5.2014	37,02	35,13	31,46	28,30	29,88	Tasa 2
25.5.2014	17,34	16,47	16,89	12,80	14,85	Tasa 2
26.5.2014	6,13		5,21	6,00	5,61	Tasa 2
27.5.2014		8,48	13,30	11,80	12,55	Tasa 2
28.5.2014	8,03	9,11	11,04	9,80	10,42	Tasa 2
29.5.2014	7,34	8,02	9,90	8,70	9,30	Tasa 2
30.5.2014	14,14	14,56	16,49	11,60	14,05	Tasa 2
31.5.2014	11,35	11,83	10,00	8,70	9,35	Tasa 2
1.6.2014	7,56	7,39	8,71	7,80	8,25	Tasa 2
2.6.2014	9,28		11,03	10,10	10,57	Tasa 2
3.6.2014	25,64		24,21	21,10	22,65	Tasa 2
4.6.2014	49,33	49,22	51,21	46,40	48,81	Tasa 2
5.6.2014	42,72	42,66	45,35	42,40	43,88	Tasa 2
6.6.2014	33,62	33,15	33,80	31,50	32,65	Tasa 2
7.6.2014	17,65	17,33	19,32	15,50	17,41	Tasa 2
8.6.2014	12,67	12,75	15,15	12,30	13,73	Tasa 2
9.6.2014	6,69	6,66	8,28	6,80	7,54	Tasa 2
10.6.2014	14,14		13,40	13,20	13,30	Tasa 2
11.6.2014	20,26	20,60				Tasa 2
12.6.2014	16,51	16,14				Tasa 2
13.6.2014	8,26	8,98				Tasa 2
14.6.2014	5,76	6,09				Tasa 2
15.6.2014	8,81	8,86				Tasa 2
16.6.2014	4,65	4,71				Tasa 2
18.6.2014	5,74	5,54	5,49	4,60	5,04	Tasa 2
19.6.2014	6,09	6,03	5,99	4,80	5,39	Tasa 2
20.6.2014	4,89	4,91	4,04	3,50	3,77	Tasa 2
21.6.2014	5,17	5,20	3,20	2,70	2,95	Tasa 2
22.6.2014	7,58	7,62	6,17	5,10	5,64	Tasa 2
23.6.2014	8,47	8,69	8,59	7,20	7,90	Tasa 2
24.6.2014	10,31	10,42	13,15	10,60	11,87	Tasa 2
25.6.2014	15,76	15,89	17,52	13,90	15,71	Tasa 2
26.6.2014	15,00	15,30	16,67	13,60	15,13	Tasa 2
27.6.2014	14,67	14,46	11,54	9,70	10,62	Tasa 2
28.6.2014	10,25	10,42	8,03	7,10	7,57	Tasa 2
29.6.2014	8,72	8,79	7,76	6,80	7,28	Tasa 2
30.6.2014	7,28	7,44	9,03	8,80	8,92	Tasa 2
1.7.2014	6,14	6,19	7,54	6,20	6,87	Tasa 2
2.7.2014	19,29	19,33	12,45	11,70	12,07	Tasa 2
3.7.2014	14,52	14,75	13,29	11,80	12,55	Tasa 2
4.7.2014	11,79	11,93	13,19	11,40	12,30	Tasa 2
5.7.2014	10,36	10,51	10,38	9,00	9,69	Tasa 2
6.7.2014	15,85	16,74	13,95	11,50	12,72	Tasa 2
7.7.2014	21,03	21,33	18,30	15,90	17,10	Tasa 2
8.7.2014	16,66	16,25	17,07	14,30	15,68	Tasa 2
9.7.2014	11,76		11,53	10,10	10,82	Tasa 2
10.7.2014	12,80		10,70	9,30	10,00	Tasa 2
11.7.2014	11,28	11,43	8,78	7,40	8,09	Tasa 2
12.7.2014	12,92	13,13	9,52	7,90	8,71	Tasa 2
13.7.2014	17,43	17,90	15,79	13,60	14,70	Tasa 2
14.7.2014	26,26	25,31	24,64	21,80	23,22	Tasa 2
5.12.2014	3,09	2,95	3,59	3,73	3,66	Savi 1
6.12.2014	3,43	3,24	3,64	3,91	3,78	Savi 1
7.12.2014	4,90	4,90	4,41	4,67	4,54	Savi 1
8.12.2014	5,24	5,16	4,19	4,45	4,32	Savi 1
9.12.2014	7,33	7,40	5,24	5,43	5,33	Savi 1
10.12.2014	10,14	9,55	8,68	9,80	9,24	Savi 1
11.12.2014	9,58	9,06	9,93	10,40	10,16	Savi 1
12.12.2014	10,36	10,25	11,81	12,39	12,10	Savi 1
13.12.2014	5,15	4,97	6,17	6,50	6,34	Savi 1
14.12.2014	5,87	6,21	5,74	5,96	5,85	Savi 1
15.12.2014	6,46	6,47	7,10	7,70	7,40	Savi 1
16.12.2014	6,33	6,38	6,27	6,67	6,47	Savi 1
17.12.2014	7,32	7,07	6,97	7,69	7,33	Savi 1
25.12.2014	10,63	11,43	4,14	4,51	4,33	Savi 1
26.12.2014	3,63	4,01	3,50	3,91	3,71	Savi 1
27.12.2014	10,20	9,75	6,82	7,70	7,26	Savi 1
28.12.2014	30,73	29,70	16,21	35,63	25,92	Savi 1
29.12.2014	30,85	29,57	18,66	25,80	22,23	Savi 1
30.12.2014	2,46	3,63	3,54	3,88	3,71	Savi 1
31.12.2014	4,00	3,97	2,92	3,12	3,02	Savi 1
1.1.2015	2,53	2,91	3,37	3,57	3,47	Savi 1
2.1.2015	1,55	1,70	1,43	1,58	1,51	Savi 1
3.1.2015	3,46	3,97	3,25	3,65	3,45	Savi 1
4.1.2015	9,35	9,25	7,76	8,48	8,12	Savi 1
5.1.2015	10,07	9,55	8,50	8,80	8,65	Savi 1
6.1.2015	43,06	40,07	15,83	13,04	14,43	Savi 1
7.1.2015	5,50	6,00	5,37	6,02	5,70	Savi 1
9.1.2015	6,91		6,87	7,56	7,21	Savi 1
10.1.2015	9,24		8,26	8,81	8,54	Savi 1
11.1.2015	13,29		14,22	15,61	14,92	Savi 1
12.1.2015	33,02		20,04	39,27	29,65	Savi 1
13.1.2015	26,97		16,86	25,01	20,94	Savi 1
14.1.2015	5,76		5,28	5,69	5,49	Savi 1
15.1.2015	5,27		3,69	4,03	3,86	Savi 1
16.1.2015	5,82		4,55	4,90	4,73	Savi 1
17.1.2015	8,80		7,29	8,03	7,66	Savi 1
18.1.2015	3,72		3,38	3,67	3,53	Savi 1
19.1.2015	29,37		20,53	14,68	17,61	Savi 1
20.1.2015	57,97		32,65	19,03	25,84	Savi 1
21.1.2015	37,80		17,29	17,93	17,61	Savi 1
22.1.2015	65,57		24,14	23,17	23,65	Savi 1
23.1.2015	23,68		12,74	14,24	13,49	Savi 1
24.1.2015	9,14		7,69	8,30	7,99	Savi 1
25.1.2015	7,46		8,39	8,99	8,69	Savi 1
26.1.2015	4,98		4,55	5,00	4,77	Savi 1
27.1.2015	3,74		3,55	3,89	3,72	Savi 1
28.1.2015	3,59		2,78	3,03	2,90	Savi 1
29.1.2015	11,81		14,48	15,40	14,94	Savi 1
30.1.2015	10,31		13,22	14,19	13,71	Savi 1
31.1.2015	6,93		7,46	8,19	7,82	Savi 1
1.2.2015	4,99		5,07	5,47	5,27	Savi 1
2.2.2015	7,66		8,21	8,92	8,57	Savi 1
3.2.2015	13,04		16,06	17,05	16,55	Savi 1
4.2.2015	12,83		12,78	13,81	13,30	Savi 1
5.2.2015	7,71		7,29	7,94	7,62	Savi 1

Date	Leckel R1 (09/0081) PM10	Leckel R2 (11/0070) PM10	Grimm 180 B-5 PM10	Grimm 180 C-1 PM10	Grimm 180 B + C average PM10	Campaign
6.2.2015	3,625566636		1,9751125	2,185138889	2,080125695	Savi 2
7.2.2015	3,622189993		2,476141667	2,851527778	2,663834723	Savi 2
8.2.2015	38,05530372		17,23444583	31,49881944	24,36663264	Savi 2
9.2.2015	15,20311933		9,112975	13,78951389	11,45124445	Savi 2
10.2.2015	4,36343852		2,036470833	2,818680556	2,427575695	Savi 2
11.2.2015	5,967011057		4,206991667	4,409513889	4,308252778	Savi 2
12.2.2015	34,92384406		28,7231625	34,68201389	31,7025882	Savi 2
13.2.2015	67,19804135		87,29650417	90,90506944	89,10078681	Savi 2
14.2.2015	4,233907525		3,000141667	3,193125	3,096633334	Savi 2
15.2.2015	55,01178604		40,78794167	60,89715278	50,84254723	Savi 2
16.2.2015	31,3218495		38,7168125	40,66798611	39,69239931	Savi 2
17.2.2015	16,4605621		15,19758333	16,44541667	15,8215	Savi 2
18.2.2015	6,151595243		4,258883333	4,895625	4,577254167	Savi 2
19.2.2015	6,483058525		4,7644125	5,059861111	4,912136806	Savi 2
20.2.2015	5,27203482		3,630491667	3,940486111	3,785488889	Savi 2
21.2.2015	9,138556402		9,529166667	10,24319444	9,886180554	Savi 2
22.2.2015	7,865433442		8,097529167	8,577083333	8,33730625	Savi 2
23.2.2015	8,645266594		7,782254167	8,689583333	8,23591875	Savi 2
24.2.2015	9,883046238		10,4249875	11,43729167	10,93113959	Savi 2
25.2.2015	14,70982952		14,14879167	15,51666667	14,83272917	Savi 2
5.3.2015	5,081551287		3,347970833	3,632569444	3,490270139	Savi 2
6.3.2015	4,013969521		2,674866667	2,904513889	2,789690278	Savi 2
7.3.2015	6,33230546		5,589891667	6,225416667	5,907654167	Savi 2
8.3.2015	6,308487486		5,289354167	5,716666667	5,503010417	Savi 2
9.3.2015	80,48413418		99,95464167	105,5799306	102,7672861	Savi 2
10.3.2015	13,82731725		14,38323333	16,13430556	15,25876945	Savi 2
11.3.2015	89,5428986		34,03355833	61,06680556	47,55018195	Savi 2
12.3.2015	196,1432457		189,1879875	193,0227778	191,1053827	Savi 2
13.3.2015	274,4405151		360,2203958	325,6	342,9101979	Savi 2
14.3.2015	103,869447		136,9015458	122,7922917	129,8469188	Savi 2
15.3.2015	274,8295248		216,8323542	191,6322917	204,232323	Savi 2
16.3.2015	290,6193326		292,7568208	237,0675694	264,9121951	Savi 2
17.3.2015	240,6284004		249,0509833	199,7097222	224,3803528	Savi 2
18.3.2015	150,6167484		192,4110625	148,6654167	170,5382396	Savi 2
19.3.2015	21,44255165		30,18849167	32,11152778	31,15000973	Savi 2
20.3.2015	26,8612874		34,7117375	34,86416667	34,78795209	Savi 2
21.3.2015	27,72620127		33,775025	35,55736111	34,66619306	Savi 2
22.3.2015	20,24202321		34,85680417	40,31972222	37,5882632	Savi 2
26.3.2015	39,7815446		52,23324167	48,87493056	50,55408612	Savi 2
27.3.2015	25,60290118		31,45087917	35,29520833	33,37304375	Savi 2
28.3.2015	24,09758752		26,91797917	28,52770833	27,72284375	Savi 2
29.3.2015	24,58272859		24,66195833	28,78451389	26,72323611	Savi 2
30.3.2015	12,91530649		12,4150625	14,01652778	13,21579514	Savi 2
31.3.2015	4,215352619		2,050483333	2,302222222	2,176352778	Savi 2
1.4.2015	25,30173976		22,32325	24,16722222	23,24523611	Savi 2
2.4.2015	6,422742111		6,002170833	6,570763889	6,286467361	Savi 2
3.4.2015	14,90750816		10,347075	13,77055556	12,05881528	Savi 2
4.4.2015	49,63916591		49,43533333	49,04854167	49,2419375	Savi 2
5.4.2015	59,25761421		65,56074583	65,86451389	65,71262986	Savi 2
6.4.2015	53,73345422		58,13778333	62,58284722	60,36031528	Savi 2
7.4.2015	86,38012332		105,3091042	99,19097222	102,2500382	Savi 2
8.4.2015	56,74815934		78,17929565	88,48479167	83,33204366	Savi 2
10.4.2015	20,32795796		24,1406125	26,16	25,15030625	Savi 3
11.4.2015	92,02357208		81,23196667	84,05	82,64098334	Savi 3
12.4.2015	26,28716461		27,8338875	27,36	27,59694375	Savi 3
13.4.2015	16,83079434		18,04570833	20,98	19,51285417	Savi 3
14.4.2015	17,42113851		18,84892917	19,3	19,07446459	Savi 3
15.4.2015	3,390168692		2,082679167	2,34	2,211339584	Savi 3
16.4.2015	11,51342038		7,088179167	10,64	8,864089584	Savi 3
17.4.2015	49,64823209		49,23630833	48,87	49,05315417	Savi 3
18.4.2015	47,42020312		38,97782083	43,14	41,05891042	Savi 3
19.4.2015	25,19314472		26,1913375	26,22	26,20566875	Savi 3
20.4.2015	68,7180417		67,69129167	84,98	76,33564584	Savi 3
21.4.2015	75,13601741		84,2393	81,49	82,86465	Savi 3
23.4.2015	15,72852483		11,92055417	11,54	11,73027709	Savi 3
24.4.2015	43,70602104		49,41144583	52,68	51,04572292	Savi 3
25.4.2015	50,0344515		35,063875	35,41	35,2369375	Savi 3
26.4.2015	6,508886471		5,878691667	6,33	6,104345834	Savi 3
27.4.2015	28,5197607		28,90249583	30,11	29,50624792	Savi 3
28.4.2015	49,69169387		58,22408333	58,63	58,42704167	Savi 3
29.4.2015	8,270172257		9,507691667	10,79	10,14884583	Savi 3
30.4.2015	17,34814143		20,33828333	24,1	22,21914167	Savi 3
1.5.2015	9,795067102		9,251883333	10,23	9,740941667	Savi 3
2.5.2015	1,857091041		1,369958333	1,56	1,464979167	Savi 3
3.5.2015	20,45050761		18,21652917	20,76	19,48826459	Savi 3
4.5.2015	43,67543064		46,90040417	50,56	48,73020209	Savi 3
5.5.2015	10,37044037		10,66122917	13,31	11,98561459	Savi 3
6.5.2015	16,95813701		17,2776125	20,28	18,77880625	Savi 3
7.5.2015	9,95012695		10,55860417	12	11,27930209	Savi 3
8.5.2015	10,59938339		8,675975	10,38	9,5279875	Savi 3
9.5.2015	5,954669084		4,530370833	5,69	5,110185417	Savi 3
10.5.2015	10,7869447		8,341458333	10,37	9,355729167	Savi 3
11.5.2015	11,85551124		9,002708333	11,25	10,12635417	Savi 3
12.5.2015	10,83862194		9,5959625	11,33	10,46298125	Savi 3
13.5.2015	3,974986406		3,155895833	3,59	3,372947917	Savi 3
14.5.2015	4,931121987		3,475958333	3,99	3,732979167	Savi 3
15.5.2015	10,76790571		9,020895833	9,6	9,310447917	Savi 3
16.5.2015	5,921863669		4,3178375	5,18	4,74891875	Savi 3
17.5.2015	3,992929659		2,927279167	3,4	3,163639584	Savi 3
18.5.2015	7,684429944		7,187570833	7,71	7,448785417	Savi 3
19.5.2015	16,56810882		10,10748333	11,24	10,67374167	Savi 3
20.5.2015	22,507249		17,44849583	19,56	18,50424792	Savi 3
21.5.2015	11,55094271		10,8511125	12,24	11,54555625	Savi 3

A25 Daily values of $PM_{2.5}$: Reference method, TEOM, SHARP c and MP 101

Date	Leckel R1 (09/0081) PM2,5	Leckel R2 (11/0070) PM2,5	TEOM A-9 PM2,5	TEOM B-15 PM2,5	SHARP A-21 c- dust PM2,5	SHARP B-25 c- dust PM2,5	MP101 A-29 mass conc. PM2,5	MP101 B-33 mass conc. PM2,5	Campaign
17.7.2014	8,49	8,46	9,80	9,69	9,47	8,53	10,98		Tasa 1
18.7.2014	9,03	9,54	9,93	9,79	11,01	11,32	10,70	16,16	Tasa 1
19.7.2014	8,30	8,46	8,65	8,57	9,79	9,65	8,18	12,75	Tasa 1
20.7.2014	6,74	6,84	6,95	7,02	6,31	6,36	5,90	9,23	Tasa 1
21.7.2014	6,32	6,77	7,71	7,73	7,53	7,38	8,26	10,75	Tasa 1
22.7.2014	9,52	9,88	9,82	9,93	9,73	10,13	8,37	11,50	Tasa 1
23.7.2014	10,66	11,02	11,76	11,57	11,45	11,04	12,80	14,60	Tasa 1
24.7.2014	12,64	13,10	12,73	12,57	14,05	13,79	12,79	17,22	Tasa 1
25.7.2014	10,56	10,84	10,41	10,42	11,47	10,80	11,85	13,79	Tasa 1
26.7.2014	13,20		11,39	11,41	13,06	14,71			Tasa 1
27.7.2014	12,70								Tasa 1
28.7.2014	14,25								Tasa 1
29.7.2014	8,38	8,51	7,73	7,61	23,95	11,50	10,65	12,20	Tasa 1
30.7.2014	9,93	9,95	10,68	10,42	9,03	8,94	11,94	13,30	Tasa 1
31.7.2014	15,07		20,22	20,55	14,25	15,26	6,55	13,96	Tasa 1
1.8.2014	8,49	8,02	8,81	8,68	9,12	9,72	10,19	13,00	Tasa 1
2.8.2014	7,22	6,65	8,28	7,96	6,96	7,20	9,18	12,07	Tasa 1
3.8.2014	11,78	11,50	13,18	12,82	11,22	12,19	12,38	15,85	Tasa 1
4.8.2014	10,47	11,12	10,87	10,98	11,07	10,20	11,48	13,86	Tasa 1
5.8.2014	11,76	13,08	13,02	12,79	10,92	12,13	12,40	15,99	Tasa 1
6.8.2014	15,26	15,94	15,42	15,14	12,23	15,67	16,28	19,34	Tasa 1
7.8.2014	14,45	15,17	14,44	14,17	14,84	14,80	14,93	18,82	Tasa 1
8.8.2014	9,63	9,74	9,45	9,23	10,72	10,91	10,06	13,05	Tasa 1
9.8.2014	7,27	7,43	7,50	7,33	8,29	8,16	8,66	12,15	Tasa 1
10.8.2014	10,28	10,59	10,95	10,90	8,88	9,42	9,52	12,87	Tasa 1
11.8.2014	14,04		14,99	15,35	13,99	12,46	18,59	21,98	Tasa 1
12.8.2014	6,95								Tasa 1
13.8.2014	6,52	6,65	7,64	7,34	6,96	6,80	9,62	12,49	Tasa 1
14.8.2014	8,18	8,16	9,50	9,20	6,80	7,07	8,42	9,33	Tasa 1
15.8.2014	5,82	5,71	6,21	6,40	6,06	6,14	7,39	9,16	Tasa 1
16.8.2014	3,41	3,43	4,70	4,64	3,48	4,11	4,59	6,25	Tasa 1
17.8.2014	4,02	4,03	5,24	6,26	3,58	4,45	3,58	5,72	Tasa 1
18.8.2014	6,79	6,88	8,63	8,13	6,90	7,28	7,24	9,50	Tasa 1
19.8.2014	4,92	4,93	6,66	6,48	5,42	4,13	5,91	7,87	Tasa 1
20.8.2014	6,19	6,35	8,98	8,72	6,60	5,74	7,41	10,11	Tasa 1
21.8.2014	5,33	5,42	8,10	7,85	5,53	4,58	7,38	7,69	Tasa 1
22.8.2014		5,71	8,47	8,23	6,17	5,57	7,25	7,89	Tasa 1
23.8.2014	6,44	6,64	9,04	8,72	6,88	8,49	7,70	8,33	Tasa 1
24.8.2014	5,38	5,49	7,54	7,36	5,85	5,80	6,83	8,17	Tasa 1
25.8.2014	6,84	6,99	7,46	7,22	7,25	7,73	5,29	7,11	Tasa 1
26.8.2014		4,17	5,88	5,71	4,90	4,99	3,89	6,08	Tasa 1
27.8.2014	3,10	3,20	5,56	5,58	3,78	3,07	4,10	6,51	Tasa 1
28.8.2014	4,03	4,16	6,18	6,06	4,64	4,90	5,06	7,80	Tasa 1
29.8.2014	4,82	5,06	7,27	6,99	4,86	7,70	6,37	8,93	Tasa 1
30.8.2014	4,39	4,62	7,18	6,90	4,59	4,98	5,62	8,24	Tasa 1
31.8.2014	5,57	5,56	8,08	7,64	4,73	5,08	5,83	7,76	Tasa 1
1.9.2014	7,28	7,57	10,41	9,92	7,10	7,43	8,48	10,23	Tasa 1
2.9.2014	7,95	8,11	10,95	10,45	8,51	7,74	9,18	10,62	Tasa 1
3.9.2014	6,65	7,15	8,57	8,47	6,49	6,11	7,81	9,28	Tasa 1
4.9.2014	8,55	9,01	9,59	9,25	7,38	8,26	7,79	11,98	Tasa 1
5.9.2014	7,59	7,84	9,42	9,08			8,41	11,88	Tasa 1
6.9.2014	7,44	7,77	10,06	9,59			10,46	11,50	Tasa 1
7.9.2014	7,94	8,41	10,01	9,78			8,47	9,89	Tasa 1
8.9.2014	11,28	12,04	13,45	13,35			12,66	15,13	Tasa 1
24.9.2014	5,68	5,73	8,84	8,40	3,46	5,44	7,26	7,62	Tasa 1
25.9.2014	9,23	9,35	12,57	12,10	10,88	10,32	10,78	12,75	Tasa 1
26.9.2014	7,72	7,52	8,89	8,55	6,05	7,24			Tasa 1
27.9.2014	5,23	5,25	8,45	8,18	1,93	5,25	6,59	7,12	Tasa 1
28.9.2014	4,29	4,28	7,56	7,30	-0,41	4,00	4,66	6,31	Tasa 1
29.9.2014	5,20	5,08	8,92	8,62	2,27	5,92	8,65	9,06	Tasa 1
30.9.2014	4,12	4,17	8,03	7,62	5,23	4,98	7,98	7,14	Tasa 1
1.10.2014	6,04	6,26	8,78	8,39	5,15	6,20	7,42	7,27	Tasa 1
2.10.2014	9,14	9,03	12,78	11,92	8,93	9,18	9,60	10,77	Tasa 2
3.10.2014	7,34	7,76	11,00	10,17	7,60	8,45	10,03	9,42	Tasa 2
4.10.2014	4,78	4,85	7,58	7,12	3,15	4,79	5,86	6,14	Tasa 2
5.10.2014	10,60	10,98	13,66	12,72	13,03	11,41	12,92	12,15	Tasa 2
6.10.2014	11,03	11,39	15,53	14,26	10,66	10,36	12,75	13,02	Tasa 2
7.10.2014	10,40	10,97	11,96	12,19	10,85	10,31	9,82	10,87	Tasa 2
8.10.2014	14,57	15,60	17,82	16,68	18,89	17,09	16,12	17,25	Tasa 2
9.10.2014	9,50	10,03	13,52	12,56	10,42	10,61	12,86	14,05	Tasa 2
10.10.2014	2,11	2,30	4,72	4,55			3,51	4,34	Tasa 2
11.10.2014	4,01	4,53	8,11	7,62	6,45	5,60	7,26	7,40	Tasa 2
12.10.2014	4,97	5,44	8,55	8,01	6,26	6,43	6,19	7,84	Tasa 2
13.10.2014	4,33	4,46	7,25	6,83	2,97	3,98	6,84	5,91	Tasa 2
14.10.2014	3,64	3,90	6,49	6,12	4,85	5,00	5,83	5,77	Tasa 2
15.10.2014	3,14	3,44	6,00	5,74	3,53	3,42	4,33	6,04	Tasa 2
16.10.2014	3,61	3,99	6,30	5,97	3,54	3,11	5,90	6,13	Tasa 2
17.10.2014	6,25	6,78	9,71	9,08	7,37	6,79	10,53	10,16	Tasa 2
18.10.2014	5,52	6,02	6,89	6,80			7,25	6,70	Tasa 2
19.10.2014	1,91	1,99	3,67	3,60			2,51	1,57	Tasa 2
20.10.2014	3,51	3,88	7,06	6,69			6,14	6,11	Tasa 2
21.10.2014	4,92	5,04	7,81	7,43	7,57	4,66	9,53	9,72	Tasa 2
22.10.2014	5,40	6,03	8,89	8,56	6,06	5,41	10,04	10,97	Tasa 2
23.10.2014	9,92	10,41	8,27	8,26	6,25	5,44	11,54	12,97	Tasa 2
24.10.2014			7,47	7,33	6,78	6,99	9,11	11,89	Tasa 2
25.10.2014	8,53	9,11	11,47	10,75	10,21	10,85	8,99	9,02	Tasa 2
26.10.2014	8,76	9,60	11,78	11,21	10,52	9,69	9,23	11,93	Tasa 2
27.10.2014	3,62	3,81	6,89	6,63	2,68	2,58	5,37	5,98	Tasa 2
28.10.2014	5,97	6,33	9,50	9,18	7,66	7,88	7,01	7,47	Tasa 2
29.10.2014	7,41	8,64	11,40	10,74	7,80	7,45	12,36	13,50	Tasa 2
30.10.2014	5,47	6,65	9,50	9,25	4,68	4,65	12,35	13,31	Tasa 2
31.10.2014	3,95	4,40	7,67	6,94	6,91	6,02	8,66	9,55	Tasa 2
1.11.2014	10,78	13,29	7,13	6,95	5,85	5,38	7,70	7,48	Tasa 2
2.11.2014	4,08	4,32	6,47	6,51	5,21	5,33	2,90	3,87	Tasa 2
3.11.2014	7,91	8,51	11,41	11,02	9,00	8,90	9,63	9,78	Tasa 2
4.11.2014	7,08		10,48	9,70	8,54	7,96	8,49	9,28	Tasa 2
5.11.2014	3,93	4,14	7,91	7,40	5,16	4,28	8,22	7,96	Tasa 2
6.11.2014	3,71	3,60	5,09	5,02	3,05	2,90	4,35	3,50	Tasa 2
7.11.2014	3,05	3,29	5,76	5,53	3,43	3,59	3,58	3,91	Tasa 2
8.11.2014	8,71	9,11	11,67	10,89	8,91	9,01	13,95	11,66	Tasa 2
9.11.2014	5,41	5,62	9,10	8,63	5,79	5,36			Tasa 2
10.11.2014	6,35	6,57	8,54	8,08	5,85	5,81	6,78	6,69	Tasa 2
11.11.2014	3,22	3,35	7,38	6,98	2,96	3,72	6,22	5,74	Tasa 2
12.11.2014	3,39	3,20	6,78	6,17	5,50	4,78	5,64	6,37	Tasa 2
13.11.2014	5,62	6,22	6,31	8,92	4,59	4,54	6,99	8,42	Tasa 2
14.11.2014	7,21	8,25	9,64	8,83	7,23	7,13	11,66	12,27	Tasa 2
15.11.2014	6,15	6,94	6,74	6,25	5,02	4,52	6,40	7,45	Tasa 2
16.11.2014	6,67	7,59	11,26	9,84	7,54	6,63	7,94	9,58	Tasa 2
17.11.2014	7,24	8,24	11,26	10,24	8,34	7,66	9,54	9,56	Tasa 2
18.11.2014	7,91		12,26	11,28	9,52	8,98	9,65	11,39	Tasa 2
20.11.2014	10,55	11,66	12,03	11,48	9,22	9,03	14,67	14,29	Tasa 2
21.11.2014	6,00	6,91	8,20	7,55	6,22	6,45	5,20	7,16	Tasa 2
22.11.2014	8,60	9,27	12,26	11,41	9,19	9,80	10,97	12,23	Tasa 2
23.11.2014	6,66	7,28	9,40	8,74	6,19	6,14			Tasa 2
24.11.2014	9,97	11,75	12,99	11,99	10,78	10,30	11,15	10,25	Tasa 2
25.11.2014	9,57	12,15	14,19	13,28	11,21	10,65	12,26	14,91	Tasa 2
26.11.2014	7,12	8,26	11,94	11,31	9,71	7,36	8,83	9,86	Tasa 2
27.11.2014	6,94	8,06	12,38	11,96	7,71	6,40	9,96	11,88	Tasa 2
28.11.2014	6,00	7,05	9,70	9,07	7,35	6,46	7,22	9,44	Tasa 2
29.11.2014	6,52	7,56	9,21	8,83	8,36	6,64	11,55	11,31	Tasa 2
30.11.2014	5,29	5,70	8,01	7,45	6,48	5,96	6,52	6,97	Tasa 2
1.12.2014	5,63	6,19	7,53	7,09	5,58	5,26	7,35	6,03	Tasa 2

Date	Leckel R1 (09/0081) PM2,5	Leckel R2 (11/0070) PM2,5	TEOM A-9 PM2,5	TEOM B-15 PM2,5	SHARP A-21 c- dust PM2,5	SHARP B-25 c- dust PM2,5	MP101 A-29 mass conc. PM2,5	MP101 B-33 mass conc. PM2,5	Campaign
10.4.2015		3,23	5,23	5,29	4,65	1,88	4,75	4,98	Savi 1
11.4.2015		11,42	11,54	12,04	10,65	12,93	16,61	19,85	Savi 1
12.4.2015		6,30	7,44	7,65	6,83	6,50	7,13	9,74	Savi 1
13.4.2015		2,55	4,53	4,46	2,90	0,53	5,48	4,69	Savi 1
14.4.2015		2,95	4,71	4,82	3,10	2,55	4,46	4,68	Savi 1
15.4.2015		1,76	3,51	3,58	2,67	1,06	3,15	2,34	Savi 1
16.4.2015		2,87	6,96	6,83	3,99	2,49	5,30	6,59	Savi 1
17.4.2015		9,04	9,88	9,90	7,86	8,26	23,91	14,60	Savi 1
18.4.2015		7,87	8,63	8,73	7,59	7,21	20,78	13,65	Savi 1
19.4.2015		4,76	5,04	5,16	2,83	0,94	5,79	6,59	Savi 1
20.4.2015		12,53	7,97	8,28	7,95	5,93	12,35	14,29	Savi 1
21.4.2015		9,70	7,94	8,36	7,38	6,38	11,54	11,29	Savi 1
23.4.2015		2,81	5,76	5,93	2,74	1,58	4,80	4,58	Savi 1
24.4.2015		7,23	8,08	8,06	7,12	8,20	9,09	10,93	Savi 1
25.4.2015		7,52	8,90	9,08	7,28	7,01	10,26	11,28	Savi 1
26.4.2015		2,59	5,51	5,50	3,11	2,32	3,33	3,18	Savi 1
27.4.2015		4,91	6,89	7,19	4,73	5,06	3,87	4,92	Savi 1
28.4.2015		10,02	7,04	7,09	6,96	5,37	10,64	12,02	Savi 1
29.4.2015		5,27	6,63	6,56	4,82	5,28	4,57	6,21	Savi 1
30.4.2015		6,26	6,93	7,01	4,45	4,88	8,38	6,30	Savi 1
1.5.2015		3,68	5,01	5,11	2,53	3,87	3,25	3,15	Savi 1
2.5.2015		1,39	3,73	3,74	2,61	0,89	3,03	2,53	Savi 1
3.5.2015		5,74	7,23	7,13	5,17	4,75	8,03	6,62	Savi 1
4.5.2015		7,12	8,50	8,78	5,21	6,78	10,17	11,99	Savi 1
5.5.2015		4,08	5,78	6,09	1,38	3,62	3,36	4,67	Savi 1
6.5.2015		9,44	12,03	12,55	11,20	10,78	9,59	11,28	Savi 1
7.5.2015		6,70	8,46	8,19	7,51	8,01	7,47	8,09	Savi 1
8.5.2015		4,56	5,34	5,37	3,69	4,09	5,30	6,08	Savi 1
9.5.2015		2,23	4,36	4,47	0,97	1,13	3,57	5,29	Savi 1
10.5.2015		3,91	6,47	6,46	1,30	4,22	3,58	5,85	Savi 1
11.5.2015		3,60	4,34	4,55	2,88	3,89			Savi 1
12.5.2015		5,38	6,59	6,61	6,04	6,90	3,69	5,59	Savi 1
13.5.2015		2,20	3,21	3,41	0,96	1,31	3,69	3,02	Savi 1
14.5.2015		2,07	4,03	3,93	1,28	1,04	3,87	4,21	Savi 1
15.5.2015		3,77	6,07	6,10	3,03	4,09	6,51	5,71	Savi 1
16.5.2015		2,90	4,50	4,59	1,76	2,26	3,23	3,66	Savi 1
17.5.2015		2,38	4,01	4,06	0,98	2,56	3,42	2,51	Savi 1
18.5.2015		4,66	7,62	7,58	5,57	6,98	5,82	7,27	Savi 1
19.5.2015		4,90	7,22	7,24	4,93	5,05	7,68	8,47	Savi 1
20.5.2015		6,54	9,03	9,12	5,09	7,23	9,01	10,67	Savi 1
21.5.2015		3,85	4,71	4,90	0,22	4,57	5,56	6,40	Savi 1
22.5.2015		5,71	5,30	5,47	-1,77	6,17	3,29	5,20	Savi 2
23.5.2015		2,70	3,22	3,16	-0,70	1,92	4,37	4,33	Savi 2
24.5.2015		3,54	5,52	5,60	0,66	3,68	4,61	5,25	Savi 2
25.5.2015		6,49	7,93	8,26	3,92	8,23	7,12	8,00	Savi 2
26.5.2015		8,14	9,68	9,79	4,83	9,73	9,35	10,89	Savi 2
27.5.2015		5,39	5,15	5,34	0,15	5,16	6,74	6,44	Savi 2
28.5.2015		5,40	5,91	6,05	-1,84	5,84	7,33	7,76	Savi 2
29.5.2015		5,53	7,32	7,24	0,54	6,78	7,20	7,06	Savi 2
30.5.2015		6,05	6,26	6,42	-0,08	6,25	5,61	8,14	Savi 2
31.5.2015		4,49	5,17	5,22	0,98	4,64	6,25	7,54	Savi 2
1.6.2015		7,63	6,62	6,69	0,64	6,86	7,93	8,65	Savi 2
2.6.2015		5,82			-0,35	6,14	5,19	7,75	Savi 2
3.6.2015		2,78	5,08	4,98	2,02	3,06	5,29	4,01	Savi 2
4.6.2015		3,16	4,50	4,57	0,08	1,85	6,62	5,67	Savi 2
5.6.2015		2,29	4,33	4,40	-0,29	1,73	4,76	4,05	Savi 2
6.6.2015		4,71	4,78	4,97	-0,56	5,30	2,84	3,05	Savi 2
7.6.2015		4,59	5,50	5,36	1,19	3,49	6,50	6,98	Savi 2
8.6.2015		3,59	4,47	4,50	1,44	2,53	5,57	4,75	Savi 2
9.6.2015		5,84	4,37	4,59	-0,05	3,48	4,77	5,18	Savi 2
10.6.2015		5,57	4,18	4,25	2,63	4,45	3,77	5,21	Savi 2
11.6.2015		4,56	4,88	5,02	0,40	3,52	5,26	5,85	Savi 2
12.6.2015		7,25	4,98	5,12			6,27	5,51	Savi 2
13.6.2015		6,17	4,37	4,41	-0,14	5,61	8,57	7,97	Savi 2
14.6.2015		4,30	4,67	4,64	2,57	5,72	4,02	3,58	Savi 2
16.6.2015		3,36	4,53	4,61	-0,61	3,39	4,91	5,21	Savi 2
18.6.2015		4,73	7,53	7,50	3,82	7,55	6,57	5,91	Savi 2
19.6.2015		11,64	13,93	14,16	13,47	14,89	13,75	16,75	Savi 2
21.6.2015		9,69	8,98	9,42	10,48	10,18	11,11	13,88	Savi 2
22.6.2015		7,74	8,11	8,06	9,03	10,70	9,99	11,53	Savi 2
23.6.2015		5,37	5,53	5,68	6,12	6,21	5,95	7,08	Savi 2
24.6.2015		4,71	4,61	4,62	3,79	4,67	5,61	6,27	Savi 2
25.6.2015		4,88	5,68	5,68	3,48	5,25	6,81	7,30	Savi 2
26.6.2015		5,79	6,93	7,05	5,18	6,70	7,34	7,66	Savi 2
27.6.2015		3,79	5,01	4,97	1,31	4,00	5,91	6,94	Savi 2
28.6.2015		4,53	5,98	6,15	1,38	4,16	5,77	7,06	Savi 2
29.6.2015		7,04	7,83	7,84	3,35	9,16	8,09	9,50	Savi 2
2.7.2015		7,99	10,10	9,42	7,87	11,23	8,67	9,82	Savi 2
3.7.2015		8,47	13,76	8,33	2,89	9,58	10,89	10,29	Savi 2
4.7.2015		3,70	2,88	2,37	2,22	4,87	5,70	6,57	Savi 2
5.7.2015		3,18	3,50	3,47	0,90	3,78	3,84	3,53	Savi 2
6.7.2015		3,44	3,31	3,44	-1,03	4,50	2,57	2,28	Savi 2
7.7.2015		3,79	6,56	6,53			5,25	5,68	Savi 2

A26 Daily values of $PM_{2.5}$: Reference method, Grimm 180

Date	Leckel R1 (09/0081) PM2,5	Leckel R2 (11/0070) PM2,5	Grimm 180 B-6 PM 2,5	Grimm 180 C-2 PM 2,5	Campaign
17.7.2014	8,49	8,46	9,18	8,23	Tasa 1
18.7.2014	9,03	9,54	11,41	10,25	Tasa 1
19.7.2014	8,30	8,46	9,25	8,19	Tasa 1
20.7.2014	6,74	6,84	7,44	6,69	Tasa 1
21.7.2014	6,32	6,77	7,88	7,15	Tasa 1
22.7.2014	9,52	9,88	10,87	9,82	Tasa 1
23.7.2014	10,66	11,02	13,45	12,33	Tasa 1
24.7.2014	12,64	13,10	14,87	12,92	Tasa 1
25.7.2014	10,56	10,84	12,1	10,95	Tasa 1
26.7.2014	13,20		15,13	13,68	Tasa 1
27.7.2014	12,70		12,48	11,64	Tasa 1
28.7.2014	14,25		16,27	14,89	Tasa 1
29.7.2014	8,38	8,51	10,31	9,33	Tasa 1
30.7.2014	9,93	9,95	12,35	11,21	Tasa 1
31.7.2014	15,07				Tasa 1
1.8.2014	8,49	8,02	8,09	7,37	Tasa 1
2.8.2014	7,22	6,65	6,83	6,38	Tasa 1
3.8.2014	11,78	11,50	12,72	11,72	Tasa 1
4.8.2014	10,47	11,12	9,89	9,09	Tasa 1
5.8.2014	11,76	13,08	12,78	11,95	Tasa 1
6.8.2014	15,26	15,94	15,83	14,66	Tasa 1
7.8.2014	14,45	15,17	14,28	13,01	Tasa 1
8.8.2014	9,63	9,74			Tasa 1
9.8.2014	7,27	7,43			Tasa 1
10.8.2014	10,28	10,59			Tasa 1
11.8.2014	14,04				Tasa 1
12.8.2014	6,95		7,22	6,72	Tasa 1
13.8.2014	6,52	6,65	5,62	5,33	Tasa 1
14.8.2014	8,18	8,16	7,6	7,27	Tasa 1
15.8.2014	5,82	5,71	5,39	4,72	Tasa 1
16.8.2014	3,41	3,43	3,74	3,36	Tasa 1
17.8.2014	4,02	4,03	4,59	4,29	Tasa 1
18.8.2014	6,79	6,88	7,01	6,49	Tasa 1
19.8.2014	4,92	4,93	5,13	4,72	Tasa 1
20.8.2014	6,19	6,35	5,94	5,61	Tasa 1
21.8.2014	5,33	5,42	5,35	5,06	Tasa 1
22.8.2014		5,71	6	5,58	Tasa 1
23.8.2014	6,44	6,64	7,96	7,33	Tasa 1
24.8.2014	5,38	5,49	6,71	6,14	Tasa 1
25.8.2014	6,84	6,99	9,95	8,85	Tasa 1
26.8.2014		4,17	7,38	6,63	Tasa 1
27.8.2014	3,10	3,20	5,14	4,64	Tasa 1
28.8.2014	4,03	4,16	6,39	5,56	Tasa 1
29.8.2014	4,82	5,06	8,43	7,52	Tasa 1
30.8.2014	4,39	4,62	7,26	6,52	Tasa 1
31.8.2014	5,57	5,56	8,08	7,42	Tasa 1
1.9.2014	7,28	7,57	9,42	8,35	Tasa 1
2.9.2014	7,95	8,11	10,02	9,05	Tasa 1
3.9.2014	6,65	7,15		7,04	Tasa 1
4.9.2014	8,55	9,01		8,25	Tasa 1
5.9.2014	7,59	7,84		8,96	Tasa 1
6.9.2014	7,44	7,77			Tasa 1
7.9.2014	7,94	8,41			Tasa 1
8.9.2014	11,28	12,04			Tasa 1
24.9.2014	5,68	5,73			Tasa 1
25.9.2014	9,23	9,35			Tasa 1
26.9.2014	7,72	7,52			Tasa 1
27.9.2014	5,23	5,25			Tasa 1
28.9.2014	4,29	4,28			Tasa 1
29.9.2014	5,20	5,08			Tasa 1
30.9.2014	4,12	4,17			Tasa 1
1.10.2014	6,04	6,26			Tasa 1
9.1.2015		5,82	6,54	7,06	Savi 1-1
10.1.2015		5,29	6,77	7,18	Savi 1-1
12.1.2015		12,58	14,28	14,99	Savi 1-1
13.1.2015		9,50	12,23	12,97	Savi 1-1
14.1.2015		4,13	4,74	5,09	Savi 1-1
15.1.2015		3,19	3,34	3,62	Savi 1-1
16.1.2015		2,89	3,87	4,12	Savi 1-1
17.1.2015		4,37	6,39	6,90	Savi 1-1
18.1.2015		2,26	2,87	3,05	Savi 1-1
19.1.2015		8,86	13,63	11,45	Savi 1-1
20.1.2015		17,63	23,14	17,30	Savi 1-1
21.1.2015		8,65	12,25	12,23	Savi 1-1
22.1.2015		12,47	16,68	15,22	Savi 1-1
23.1.2015		9,01	10,23	10,83	Savi 1-1
24.1.2015		5,73	7,11	7,71	Savi 1-1
25.1.2015		6,59	8,25	8,84	Savi 1-1
26.1.2015		3,98	4,33	4,72	Savi 1-1
27.1.2015		2,83	3,35	3,65	Savi 1-1
28.1.2015		1,73	2,50	2,72	Savi 1-1
29.1.2015		10,08	13,81	14,63	Savi 1-1
30.1.2015		7,96	12,41	13,27	Savi 1-1
31.1.2015		7,18	7,22	7,87	Savi 1-1
1.2.2015		4,96	4,94	5,32	Savi 1-1
2.2.2015		6,39	7,96	8,59	Savi 1-1
3.2.2015		11,11	15,41	16,29	Savi 1-1
4.2.2015		8,51	11,34	12,17	Savi 1-1
5.2.2015		7,48	6,92	7,47	Savi 1-1
6.2.2015		2,34	1,81	1,97	Savi 1-1
7.2.2015		1,27	2,03	2,27	Savi 1-1
8.2.2015		5,30	7,90	7,74	Savi 1-1
9.2.2015		3,18	4,33	4,75	Savi 1-1
10.2.2015		1,53	1,42	1,54	Savi 1-1
11.2.2015		2,69	2,42	2,64	Savi 1-1
12.2.2015		4,50	6,73	7,37	Savi 1-1
13.2.2015		9,54	15,15	16,26	Savi 1-1
14.2.2015		2,35	2,55	2,78	Savi 1-1
15.2.2015		9,49	15,19	16,00	Savi 1-1
16.2.2015		5,64	8,86	9,77	Savi 1-1
17.2.2015		8,30	10,82	11,74	Savi 1-1
18.2.2015		3,02	3,45	3,83	Savi 1-1
19.2.2015		3,19	3,92	4,19	Savi 1-1
20.2.2015		2,85	3,17	3,42	Savi 1-1
21.2.2015		7,15	9,17	9,77	Savi 1-1

Date	Leckel R1 (09/0081) PM2,5	Leckel R2 (11/0070) PM2,5	Grimm 180 B-6 PM 2,5	Grimm 180 C-2 PM 2,5	Campaign
22.2.2015		6,21	7,48	7,95	Savi 2-2
23.2.2015		6,14	7,10	7,69	Savi 2-2
24.2.2015		7,03	8,93	9,69	Savi 2-2
25.2.2015		8,55	12,37	13,26	Savi 2-2
26.2.2015		8,19	10,51	11,26	Savi 2-2
27.2.2015		9,15	12,32	13,10	Savi 2-2
28.2.2015		9,92	13,36	14,14	Savi 2-2
1.3.2015		10,90	13,00	13,82	Savi 2-2
2.3.2015		9,74	11,64	12,32	Savi 2-2
3.3.2015		4,04	5,83	6,25	Savi 2-2
4.3.2015		2,04	2,41	2,60	Savi 2-2
5.3.2015		2,56	2,81	3,03	Savi 2-2
6.3.2015		1,97	2,21	2,39	Savi 2-2
7.3.2015		3,75	5,35	5,89	Savi 2-2
8.3.2015		3,22	3,60	3,87	Savi 2-2
9.3.2015		6,66	12,13	13,07	Savi 2-2
10.3.2015		3,33	4,38	4,82	Savi 2-2
11.3.2015		8,67	16,63	14,07	Savi 2-2
12.3.2015		19,01	32,93	34,78	Savi 2-2
13.3.2015		34,83	49,33	51,88	Savi 2-2
14.3.2015		15,10	24,02	25,16	Savi 2-2
15.3.2015		32,20	54,98	56,64	Savi 2-2
16.3.2015		46,59	59,62	60,00	Savi 2-2
17.3.2015		46,93	53,31	53,72	Savi 2-2
18.3.2015		23,41	39,54	40,51	Savi 2-2
19.3.2015		9,50	9,93	11,39	Savi 2-2
20.3.2015		5,77	4,42	4,68	Savi 2-2
21.3.2015		8,36	6,10	6,34	Savi 2-2
22.3.2015		15,39	8,43	10,28	Savi 2-2
26.3.2015		12,99	8,98	9,50	Savi 2-2
27.3.2015		19,98	13,33	14,72	Savi 2-2
28.3.2015		18,09	24,52	26,27	Savi 2-2
29.3.2015		8,55	22,15	24,12	Savi 2-2
30.3.2015		2,39	10,41	11,61	Savi 2-2
31.3.2015		0,24	1,74	1,89	Savi 2-2
1.4.2015		7,02	10,65	11,69	Savi 2-2
2.4.2015		4,38	5,32	5,79	Savi 2-2
3.4.2015		4,69	7,29	7,83	Savi 2-2
4.4.2015		9,88	14,14	15,28	Savi 2-2
5.4.2015		8,84	15,91	16,73	Savi 2-2
6.4.2015		7,46	12,80	13,82	Savi 2-2
7.4.2015		9,50	14,84	16,02	Savi 2-2
8.4.2015		12,89	11,25	13,41	Savi 2-2
10.4.2015		3,23	4,03	4,54	Savi 1-3
11.4.2015		11,42	19,54	20,67	Savi 1-3
12.4.2015		6,30	9,62	10,32	Savi 1-3
13.4.2015		2,55	3,45	3,79	Savi 1-3
14.4.2015		2,95	4,93	5,34	Savi 1-3
15.4.2015		1,76	1,93	2,11	Savi 1-3
16.4.2015		2,87	3,74	4,02	Savi 1-3
17.4.2015		9,04	13,14	13,68	Savi 1-3
18.4.2015		7,87	11,92	12,66	Savi 1-3
19.4.2015		4,76	4,78	5,01	Savi 1-3
20.4.2015		12,53	12,70	13,91	Savi 1-3
21.4.2015		9,70	14,53	14,76	Savi 1-3
23.4.2015		2,81	3,05	3,16	Savi 1-3
24.4.2015		7,23	8,52	9,03	Savi 1-3
25.4.2015		7,52	10,81	11,40	Savi 1-3
26.4.2015		2,59	2,96	3,28	Savi 1-3
27.4.2015		4,91	7,29	7,80	Savi 1-3
28.4.2015		10,02	9,15	9,85	Savi 1-3
29.4.2015		5,27	4,85	5,57	Savi 1-3
30.4.2015		6,26	5,36	5,94	Savi 1-3
1.5.2015		3,68	4,25	4,72	Savi 1-3
2.5.2015		1,39	1,26	1,41	Savi 1-3
3.5.2015		5,74	6,17	6,76	Savi 1-3
4.5.2015		7,12	8,56	9,24	Savi 1-3
5.5.2015		4,08	3,95	4,48	Savi 1-3
6.5.2015		9,44	10,35	11,64	Savi 1-3
7.5.2015		6,70	8,79	9,78	Savi 1-3
8.5.2015		4,56	5,65	6,29	Savi 1-3
9.5.2015		2,23	2,26	2,57	Savi 1-3
10.5.2015		3,91	3,69	4,25	Savi 1-3
11.5.2015		3,60	3,36	3,79	Savi 1-3
12.5.2015		5,38	6,08	6,78	Savi 1-3
13.5.2015		2,20	2,21	2,44	Savi 1-3
14.5.2015		2,07	1,99	2,22	Savi 1-3
15.5.2015		3,77	3,64	4,05	Savi 1-3
16.5.2015		2,90	2,33	2,65	Savi 1-3
17.5.2015		2,38	2,15	2,42	Savi 1-3
18.5.2015		4,66	6,48	6,93	Savi 1-3
19.5.2015		4,90	7,24	7,89	Savi 1-3
20.5.2015		6,54	7,89	8,72	Savi 1-3
21.5.2015		3,85	3,32	3,67	Savi 1-3

A27 Daily values of $PM_{2.5}$: Reference method, BAM 1020 and FH-62IR

Leckel R1 (09/0081) PM2,5	Leckel R2 (11/0070) PM2,5	BAM A-21 conc. PM2,5	BAM B-25 conc. PM2,5	FH-62 A-29 conc. PM2,5	FH-62 B-33 conc. PM2,5	Campaign
8,49	8,46			7,89	7,72	Tasa 1
9,03	9,54			10,45	8,37	Tasa 1
8,30	8,46			7,67	6,51	Tasa 1
6,74	6,84			5,3	5,37	Tasa 1
6,32	6,77			7,1	6,31	Tasa 1
9,52	9,88			10,36	9,77	Tasa 1
10,66	11,02			10,1	8,64	Tasa 1
12,64	13,10	11,14	10,62	14,27	12,34	Tasa 1
10,56	10,84	9,3	7,67	8,1	8,26	Tasa 1
13,20		10,75	10,41	11,89	11,8	Tasa 1
12,70		9,75	8,96	8,09	8,25	Tasa 1
14,25		11,38	10,21	13,5	10,84	Tasa 1
8,38	8,51	6,9	6,79	13,31	9,87	Tasa 1
9,93	9,95	7,76	6,14	-0,78	2,84	Tasa 1
15,07						Tasa 1
8,49	8,02	5,08	5,16	3,78	3,87	Tasa 1
7,22	6,65	5,16	4,71	3,5	4,06	Tasa 1
11,78	11,50	10,51	10,14	11,11	10,77	Tasa 1
10,47	11,12	9,33	7,6	10,82	10,61	Tasa 1
11,76	13,08	11,42	9,22	21,74	16,65	Tasa 1
15,26	15,94	12,75	12,8			Tasa 1
14,45	15,17	11,54	12,62			Tasa 1
9,63	9,74	7,2	7,12	1,41	4,73	Tasa 1
7,27	7,43	5,37	4,5	6,07	5,55	Tasa 1
10,28	10,59	7,97	6,76	9,51	8,83	Tasa 1
14,04		12,29	11,29	13,74	11,27	Tasa 1
6,95		5,58	4,59	5,03	3,99	Tasa 1
6,52	6,65	3,88	3,54	2,92	3,31	Tasa 1
8,18	8,16	6,21	4,92	5,75	5,97	Tasa 1
5,82	5,71	3,7	2,99	4,09	4,68	Tasa 1
3,41	3,43	2,12	1,17	-0,38	1,56	Tasa 1
4,02	4,03	2,59	1,46	4,72	4,08	Tasa 1
6,79	6,88	4,75	4,16	4,73	5,33	Tasa 1
4,92	4,93	3,13	2,42	5,95	2,18	Tasa 1
6,19	6,35	4,54	4,08	2,48	3,66	Tasa 1
5,33	5,42	4,3	3,38	6,11	5,25	Tasa 1
	5,71	4,99	3,66	1,53	2,95	Tasa 1
6,44	6,64	5,71	4,63	7,57	5,91	Tasa 1
5,38	5,49	4,12	3,92	3,74	3,22	Tasa 1
6,84	6,99	5,62	5,74	6,96	6,43	Tasa 1
	4,17	3,75	2,54	4,77	4,84	Tasa 1
3,10	3,20	1,92	1,34	3,59	3,5	Tasa 1
4,03	4,16	3,29	2,08	-0,76	1,18	Tasa 1
4,82	5,06	5,04	3,46	4,02	3,63	Tasa 1
4,39	4,62	3,79	3,33	3,46	3,73	Tasa 1
5,57	5,56	4,72	4,05	4,64	4,61	Tasa 1
7,28	7,57	6,33	5,79	5,4	5,28	Tasa 1
7,95	8,11	6,37	5,67	8,15	6,86	Tasa 1
6,65	7,15	5,46	4,58	9,01	6,35	Tasa 1
8,55	9,01	6,17	5,09	2,97	6,9	Tasa 1
7,59	7,84	6,25	4,83	4,16	5,14	Tasa 1
7,44	7,77			4,68	6,19	Tasa 1
7,94	8,41					Tasa 1
11,28	12,04	10,57	9	16,96	11,87	Tasa 1
5,68	5,73	3,46	3,21	7,64	6,38	Tasa 1
9,23	9,35	7,67	6,88	8,6	8,46	Tasa 1
7,72	7,52	6,03	5,11	6,46	6,27	Tasa 1
5,23	5,25	3,29	2,96	4,71	4,77	Tasa 1
4,29	4,28	2,67	2,29	4,08	4,37	Tasa 1
5,20	5,08	4,33	3,75	3,16	3,89	Tasa 1
4,12	4,17	3,34	2,29	2,14	2,4	Tasa 1
6,04	6,26	5,84	5,34	5,9	5,28	Tasa 1
9,14	9,03	7,87	7,54	10,04	9,25	Tasa 2
7,34	7,76	8,53	7,41	5,63	5,93	Tasa 2
4,78	4,85	2,79	3,33	4,35	4,02	Tasa 2
10,60	10,98	9,59	9,3	9,62	9,03	Tasa 2
11,03	11,39	11,34	10,97	10,93	10,25	Tasa 2
10,40	10,97	10,62	9,7	8,03	9,28	Tasa 2
14,57	15,60	13,83	14,4	16,37	14,55	Tasa 2
9,50	10,03	10,11	9,11	8,26	8,26	Tasa 2
2,11	2,30	1,92	0,54	2,31	2,35	Tasa 2
4,01	4,53	3,79	3,00	4,00	3,93	Tasa 2
4,97	5,44	5,22	3,63	5,56	5,07	Tasa 2
4,33	4,46	3,63	2,83	4,79	3,81	Tasa 2
3,64	3,90	4,16	2,20	1,36	1,96	Tasa 2
3,14	3,44	2,46	1,79	1,28	1,11	Tasa 2
3,61	3,99	2,33	2,00	3,03	3,04	Tasa 2
6,25	6,78	7,55	5,67	5,65	5,89	Tasa 2
5,52	6,02	4,20	4,04	7,22	6,07	Tasa 2
1,91	1,99					Tasa 2
3,51	3,88	2,39	1,23	12,49	9,74	Tasa 2
4,92	5,04	2,59	2,51	1,65	1,66	Tasa 2
5,40	6,03	5,29	5,50	4,05	4,49	Tasa 2
9,92	10,41	4,13	3,71	7,64	8,64	Tasa 2
		3,67	3,96	6,34	8,70	Tasa 2
8,53	9,11	7,76	7,26	9,39	8,54	Tasa 2
8,76	9,60	9,20	8,28	11,77	10,94	Tasa 2
3,62	3,81			0,80	2,37	Tasa 2
5,97	6,33			7,34	6,91	Tasa 2
7,41	8,64			3,19	4,93	Tasa 2
5,47	6,65			4,52	5,08	Tasa 2
3,95	4,40					Tasa 2
10,78	13,29			5,39	10,41	Tasa 2
4,08	4,32			10,60	7,64	Tasa 2
7,91	8,51			7,46	7,56	Tasa 2
7,08		5,49	6,34	2,31	4,25	Tasa 2
3,93	4,14	3,26	2,75	2,54	1,83	Tasa 2
3,71	3,60	3,00	2,25	2,29	2,80	Tasa 2
3,05	3,29	2,88	2,88	4,09	3,11	Tasa 2
8,71	9,11	9,00	7,00	8,82	7,88	Tasa 2
5,41	5,62	4,38	4,38	8,56	7,31	Tasa 2
6,35	6,57	5,24	3,87	4,14	5,04	Tasa 2
3,22	3,35	2,37	1,50	3,34	3,54	Tasa 2
3,39	3,20	2,63	2,75	-1,19	0,42	Tasa 2
5,62	6,22	4,51	3,13	3,25	3,17	Tasa 2
7,21	8,25	6,12	5,37	6,66	6,25	Tasa 2
6,15	6,94	4,25	2,38	5,40	5,12	Tasa 2
6,67	7,59	7,13	6,38	7,40	7,08	Tasa 2
7,24	8,24	8,25	7,50	6,61	7,06	Tasa 2
7,91		9,18	7,88	8,37	7,62	Tasa 2
10,55	11,66	8,87	7,99	6,15	8,06	Tasa 2
6,00	6,91	5,00	4,87	5,83	6,01	Tasa 2
8,60	9,27	8,63	7,63	8,02	7,44	Tasa 2

Date	Leckel R1 (09/0081) PM2,5	Leckel R2 (11/0070) PM2,5	BAM A-21 conc. PM2,5	BAM B-25 conc. PM2,5	FH-62 A-29 conc. PM2,5	FH-62 B-33 conc. PM2,5	Campaign
10.4.2015		3,23	0,67	0,13			Savi 1
11.4.2015		11,42	7,05	6,05			Savi 1
12.4.2015		6,30	4,79	4,57			Savi 1
13.4.2015		2,55	-0,09	-0,71			Savi 1
14.4.2015		2,95	1,17	-0,04	2,65	1,82	Savi 1
15.4.2015		1,76	0,41	-0,88	1,47	1,56	Savi 1
16.4.2015		2,87	0,92	0,21	3,99	2,48	Savi 1
17.4.2015		9,04	4,42	3,72	8,66	5,19	Savi 1
18.4.2015		7,87	5,49	4,20	10,38	8,11	Savi 1
19.4.2015		4,76	-0,29	-0,71	4,38	2,78	Savi 1
20.4.2015		12,53	2,25	2,30	7,81	3,43	Savi 1
21.4.2015		9,70	4,12	3,04	10,72	6,95	Savi 1
23.4.2015		2,81	-0,12	-0,66	3,73	3,79	Savi 1
24.4.2015		7,23	2,55	1,55	7,90	4,48	Savi 1
25.4.2015		7,52	5,08	4,20	6,40	4,54	Savi 1
26.4.2015		2,59	1,08	0,00	4,04	2,88	Savi 1
27.4.2015		4,91	2,38	1,13	11,68	8,34	Savi 1
28.4.2015		10,02	3,00	2,16	2,46	1,13	Savi 1
29.4.2015		5,27	1,46	1,09	-0,17	-0,51	Savi 1
30.4.2015		6,26	3,34	2,12	11,29	7,49	Savi 1
1.5.2015		3,68	1,95	1,20	4,11	3,65	Savi 1
2.5.2015		1,39	-0,42	-1,34	-1,84	-1,34	Savi 1
3.5.2015		5,74	1,42	1,47	6,78	4,25	Savi 1
4.5.2015		7,12	3,50	2,58	8,28	5,23	Savi 1
5.5.2015		4,08	2,17	0,96	7,13	4,87	Savi 1
6.5.2015		9,44	7,57	7,85	4,11	5,71	Savi 1
7.5.2015		6,70	5,63	4,50	3,61	3,94	Savi 1
8.5.2015		4,56	3,74	2,62	1,70	3,20	Savi 1
9.5.2015		2,23	1,75	0,75	4,27	4,10	Savi 1
10.5.2015		3,91	2,25	1,37	4,63	3,56	Savi 1
11.5.2015		3,60	2,38	1,50	1,67	2,24	Savi 1
12.5.2015		5,38	4,88	3,87	5,87	5,50	Savi 1
13.5.2015		2,20	1,37	0,37	0,59	1,07	Savi 1
14.5.2015		2,07	1,00	-0,87	2,92	0,78	Savi 1
15.5.2015		3,77	2,00	0,38	3,04	2,61	Savi 1
16.5.2015		2,90	1,75	0,62	3,58	3,14	Savi 1
17.5.2015		2,38	1,00	0,12	0,02	0,20	Savi 1
18.5.2015		4,66	4,14	3,13	8,34	5,52	Savi 1
19.5.2015		4,90	3,87	2,87	6,69	6,30	Savi 1
20.5.2015		6,54	5,75	4,25	9,53	8,67	Savi 1
21.5.2015		3,85	2,87	2,00	7,73	7,11	Savi 1
22.5.2015		5,71	2,87	1,00	11,92	9,84	Savi 2
23.5.2015		2,70	0,50	-0,50	-1,76	-0,07	Savi 2
24.5.2015		3,54	1,13	0,75	4,85	3,41	Savi 2
25.5.2015		6,49	4,00	3,50	12,02	11,15	Savi 2
26.5.2015		8,14	5,25	4,50	6,56	6,34	Savi 2
27.5.2015		5,39	3,12	2,12	6,73	6,96	Savi 2
28.5.2015		5,40	2,75	1,75	5,43	6,30	Savi 2
29.5.2015		5,53	3,38	3,00	3,90	3,33	Savi 2
30.5.2015		6,05	2,88	1,88	7,13	5,86	Savi 2
31.5.2015		4,49	2,25	1,37	3,27	3,06	Savi 2
1.6.2015		7,63	3,62	3,25	9,89	7,91	Savi 2
2.6.2015		5,82	2,29	2,57	-5,82	-2,79	Savi 2
3.6.2015		2,78			1,81	1,94	Savi 2
4.6.2015		3,16	2,25	-0,37	4,73	2,22	Savi 2
5.6.2015		2,29			3,21	3,56	Savi 2
6.6.2015		4,71		4,37	3,74	2,61	Savi 2
7.6.2015		4,59		2,63	1,84	0,77	Savi 2
8.6.2015		3,59		2,50	5,39	3,89	Savi 2
9.6.2015		5,84		2,88	6,43	3,40	Savi 2
10.6.2015		5,57		3,75	4,95	3,55	Savi 2
11.6.2015		4,56		2,25	6,40	3,98	Savi 2
12.6.2015		7,25		2,37	6,70	4,33	Savi 2
13.6.2015		6,17		2,75	5,92	4,24	Savi 2
14.6.2015		4,30		2,38	2,59	1,13	Savi 2
16.6.2015		3,36	1,21	-0,37	6,07	4,29	Savi 2
18.6.2015		4,73	2,50	2,26	3,44	2,66	Savi 2
19.6.2015		11,64	11,05	10,63	13,94	13,09	Savi 2
21.6.2015		9,69	8,79	8,12	9,41	9,04	Savi 2
22.6.2015		7,74	6,04	5,75	9,13	6,35	Savi 2
23.6.2015		5,37	4,21	3,13	4,38	4,99	Savi 2
24.6.2015		4,71	3,91	2,74	13,36	11,74	Savi 2
25.6.2015		4,88	3,33	2,13	1,73	2,82	Savi 2
26.6.2015		5,79	4,04	3,12	7,32	6,50	Savi 2
27.6.2015		3,79	2,17	1,62	3,84	2,98	Savi 2
28.6.2015		4,53	2,04	0,63	6,45	5,80	Savi 2
29.6.2015		7,04	3,83	3,25	9,43	9,57	Savi 2
2.7.2015		7,99	6,00	5,83	3,87	7,73	Savi 2
3.7.2015		8,47	6,82	5,82	2,73	3,92	Savi 2
4.7.2015		3,70	2,28	2,53	4,05	1,45	Savi 2
5.7.2015		3,18	1,17	1,42	2,74	2,65	Savi 2
6.7.2015		3,44	2,46	2,04	3,83	4,36	Savi 2
7.7.2015		3,79	2,09	1,87	3,06	2,47	Savi 2

A28 Findings from the audit surveillance study

The findings and the responses from the audit report (in Finnish) are reported here.

- The logbook at the site covers the description of the both measurement cabins and the installation of the instruments as well as their connection to the data acquisition system. Visits and activities have been recorded accordingly. However, some of the error messages have not been recorded.
    - The normal procedure is to remark the information from the instruments during the visits. The error messages from the instruments are normally collected by the data software.
- The inside temperature recording was not functional in one of the measurement cabin.
    - The cause was a lack of temperature sensor that could be connected to the data acquisition system. The manual temperature probe exist. The inside temperature was controlled by the air conditioning system.
- The sampling flow rate of the size selective instruments were checked regularly. The sampling flowrate of the MP 101 was lower than required at the beginning of the campaign. The missing flowrates of SHARP A was also observed.
    - The problem with the flow rate was the difficulty in adjusting the flowrate with MP 101 A based on the calibration of the flowrate. The technician from the representative company finally solved the problem by changing the sampling pump. The influence on the results (Tasa 1 and Tasa 2) is not significant.
- The temperature, pressure and humidity sensors of the CMs were checked between the same type of CMs to see if there is any differences. The

maximum deviation of pressure sensors was 3 kPa, which was slightly more than requirement (= 2 kPa).

- Calibration of the sensors of CMs were not calibrated within a year.
  - Calibration of the sensors were on the responsibility of the manufacturer/representative.
- Leak checks of the instruments were not performed
  - This was not considered necessary since the flow rates were measured at the sampling tube and the instrument itself recorded the flow rate continuously which was stored by the software. The leak test was performed by the manufacturer/representative.

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

FINNISH METEOROLOGICAL INSTITUTE
Erik Palménin aukio 1
FIN-00560 Helsinki
tel. +358 29 539 1000
WWW.FMI.FI

FINNISH METEOROLGRAPORTTEJA 2017:1
ISBN 978-952-336-010-5 (pdf)
ISSN 0782-6079
Helsinki 2017