LIFE FROSTDEFEND

LIFE20 CCA/GR/001747

DA2.2 Report on the technical requirements

Establishment of the pilot plots, Plan of agronomic practices, QC/QA procedures for low-cost sensors

June 2022

NATIONAL CENTRE FOR SCIENTIFIC RESEARCH "DEMOKRITOS"
ΓΕΩΠΟΝΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ AGRICULTURAL UNIVERSITY OF ATHENS
INRAE la science pour la vie, l'humain, la terre
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Report on the technical requirements

Project Number	**LIFE20 CCA/GR/001747**
Project Title	**Forecasting and protecting fruit crops from frost damage**
Project Acronym	**LIFE FROSTDEFEND**
Action	**A2. Technical Planning**
Deliverable	**DA2.2 Report on the technical requirements**
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NATIONAL CENTRE FOR SCIENTIFIC RESEARCH "DEMOKRITOS" ΓΕΩΠΟΝΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ AGRICULTURAL UNIVERSITY OF ATHENS INRAE la science pour la vie, l'humain, la terre AGRICULTURAL COOPERATIVES' UNION AEGHION S.A. msensis

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Summary

The primary objective of the LIFE FROSTDEFEND project is to develop and apply the FROSTDEFEND IoT-based system for reliable frost event warnings. The tool will be developed and initially tested in Aeghion, Greece. Two commercial and two experimental plots have been selected as pilot fields for the development and initial application of the tool. This document encompasses all the details regarding the selection and establishment of the pilot plots, as well as the plan for agronomic practices to ensure comparable results.

The FROSTDEFEND tool will utilize real-time monitoring of specific air-quality pollutants (particulate matter, PM) and critical meteorological parameters (temperature, T; relative humidity, RH) with low-cost sensors (LCSs) to predict complex processes such as the growth of epiphytic bacteria on the leaves and the frost risk.

This document:

a) Summarizes the procedure followed by the consortium to select suitable orchards for the development and testing of the tool.

b) Includes the plan of agronomic practices used in the project to ensure the maintenance of uniform sampling procedures for all experimental, commercial, and demonstration orchards involved in the project.

c) Outlines the QA/QC procedure for LCSs calibration to ensure the quality and comparability of the data obtained from LCSs.

This document, is being delivered in the context of Action A2 "Technical Planning".

1 Establishment of the pilot/test plots

1.1 Introduction

The objective of Action A2 is to define the technical requirements for the selection and establishment of the pilot plots that will act as testbeds for the development and pilot application of the FROSTDEFEND tool. To this end, four plots have been selected, two commercial orchards and two experimental plots at higher altitudes, in Aegialeia region of Greece. The high-altitude measurement campaigns are expected to provide the necessary data coverage (higher number of frost events) allowing for robust statistical data analysis. These plots fulfill specific criteria, as described below.

1.2 Selection of the experimental plots

Two commercial orchards of about 4000 m^2 each have been selected to be used as test plots for the development and pilot application of the FROSTDEFEND tool. These plots have been selected based on the specific criteria: easy access, size of the orchards (4000 m^2 each), number and variety of trees planted (Lemon trees, cultivar "Maglino"), access to electric power. The plots are located in a) Temeni and b) Valimitika in Aeghion. Figure 1 presents the commercial plots selected.

To minimize the risk of encountering no frost occurrences during the project, especially during the development, pilot implementation, and evaluation phases of the FROSTDEFEND system, two additional experimental plots have been established at higher altitudes in the Aegalia region, near the village of Kounina, at altitudes of 500m and 850m respectively, both situated in the Aigialeia region (see Figure 2). These plots were selected by ACUA in collaboration with AUA, considering factors such as their availability for long-term use, at least until the project's conclusion, their size (sufficient for accommodating 80 lemon trees), ease of access, and the availability of irrigation.

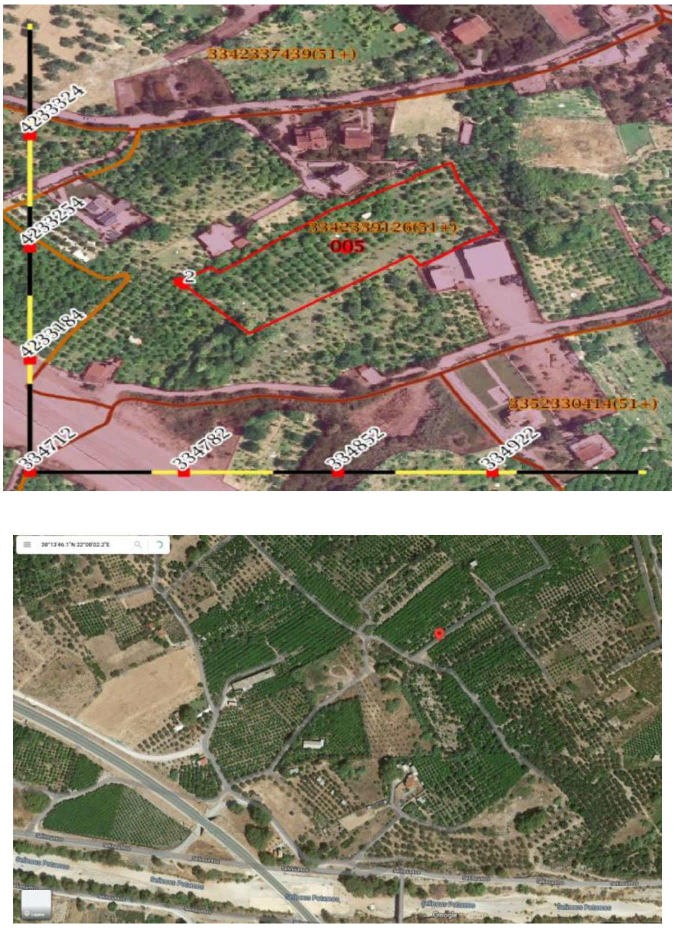


Figure 1: Commercial plots in a) Temeni and b) Valimitika, Aeghion, Greece

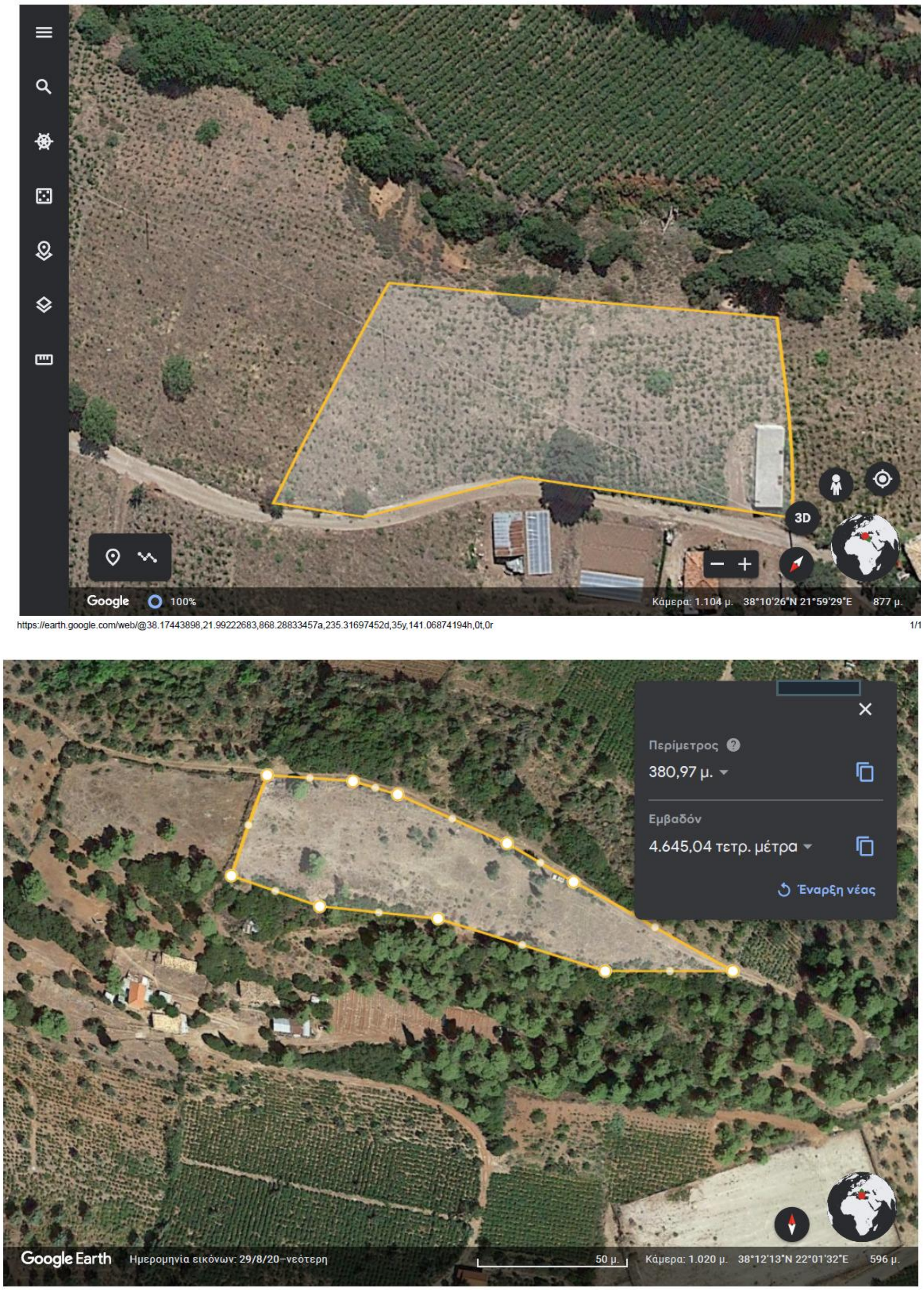


Figure 2: Experimental plots in a) Kounina (500 m) or Petrovouni and b) Kounina (850 m), Aigialeia region, Greece

1.3 Planting plan

ACUA undertook the landscaping of the plots and the planting of the trees during the spring of 2022, although the original plan was to plant them earlier (i.e., winter 2021-2022). Specifically, the first experimental plot

(Kounina, 850m) was planted on 11/05/2022 (see Figure 3), and the second one (Kounina) on 16/05/2022 (see Figure 4). These plots were not planted during the winter of 2021-2022 as initially planned in the GA due to two reasons:

1. Persistent rainy weather from late October through November 2021 prevented the use of machinery to prepare the plots and drill holes for planting trees.
2. The unavailability of 3-year-old lemon trees from the "Maglino" cultivar in the market. The necessary number of trees was purchased from two nurseries in November 2021 by ACUA and were stored on the premises of ACUA awaiting planting in April 2022.

Figure 3: Landscaping and planting of lemon trees in Kounina (850 m), Aigialeia region, Greece, on 11/05/2022

Figure 4: Landscaping and planting of lemon trees in Kounina (500 m), Aigialeia region, Greece, on 16/05/2022

The planting plan (Figure 5) involved the planting of 3 – years old lemon trees of cultivar “Maglino”. Each plot hosts 80 trees organized into two subplots of 40 trees, with a spacing of 1,5x2 meters between trees. In the center of each subplot, an empty space of 3x4 meters was designated for the installation of the air sampling instruments and the systems of sensors for real time monitoring of ambient PM, RH and T (Figure 5).

This planting density exceeds that of typical commercial orchards because the trees will not reach their full size during the project's duration, and we need to ensure sufficient foliage density to mimic real-life orchards. Figures 6 and 7 present the experimental plots in Kounina at 850m and 500m, respectively.

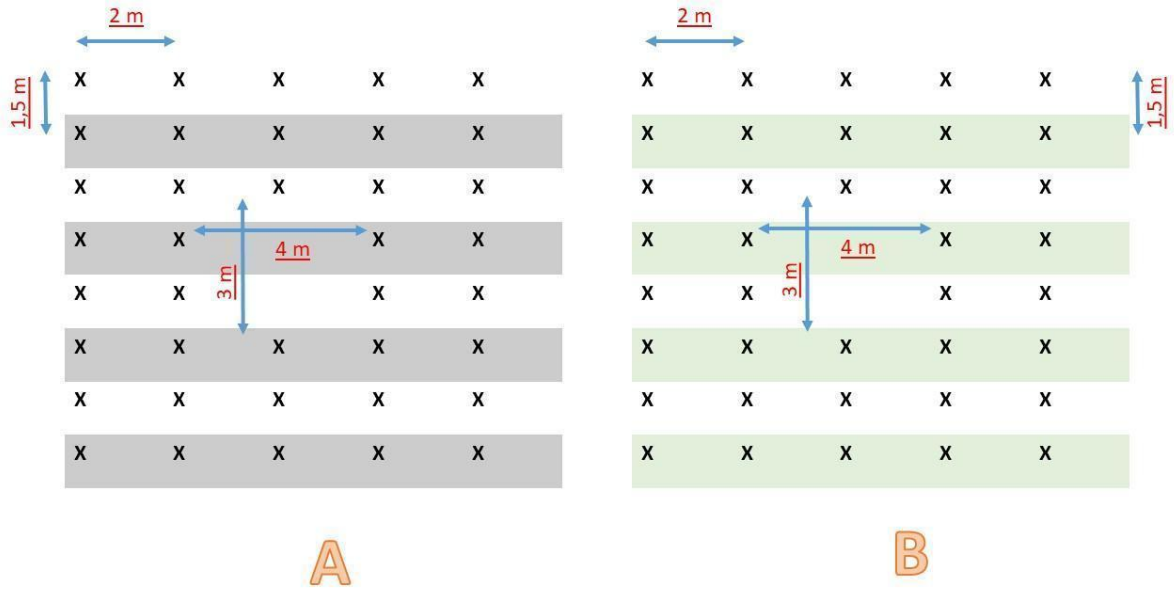


Figure 5: Planting plan

Figure 6: Experimental plot in Kounina at 850 m, Aeghion

Figure 7: Experimental plot in Kounina (500 m), Aeghion

2 Plan of Agronomic Practices for LIFE-FROSTDEFEND orchards

2.1.1 Introduction

The plan of agronomic practices is designed to maintain the uniformity of sampling procedures for all experimental, commercial and demonstration orchards utilized in the project, while also ensuring the optimal health of trees, particularly for the high-altitude orchards in Aeghion. The guideline collaboratively developed by project partners ACUA and AUA and have been communicated to the ACUA agronomists responsible for overseeing the project's activities in the orchards.

2.1.2 Sampling procedures

Sampling at the pilot orchards in Aeghion will be conducted by the ACUA agronomist under the supervision of AUA. The sampling guidelines have been devised to prevent cross-contamination of collected plant material both between consecutive samplings and, crucially, from personnel involved in sample collection.

Here are the guidelines for appropriate sampling procedures at the LIFE FROSTDEFEND orchards:

1. Leaf samples from the two commercial lemon orchards in Aeghion will be collected two to three times a week from November 1st to April 30th during the winter season and once a week during the remainder of the year. Sampling will not occur on public holidays or during personnel annual leave, unless adequately trained replacement personnel are available.
2. Aerosol samplers will be programmed to sample for 24 hours prior to leaf collection. Detailed instructions for operating the gravimetric samplers for filter sampling are provided in the deliverable "DC1.4 Technical guide for sample collection".
3. Procedure for fresh leaf and shoot sampling (Figure 8):
    a. Use a 3L ziplock plastic bag.

   b. Open the bag without touching the interior, position it over the tip of a shoot with leaves. Use an alcohol and flame-sterilized pruning scissor to cut the shoot. Repeat the process with a sample from another tree using the same bag. Each sample should comprise two pooled subsamples. Seal the bag and place it into a cooler with ice packs.
   c. Repeat the procedure taking a second sample from 2 different trees in the orchard.
4. Procedure for aerosol sample filters
   a. Filter cartridges are assembled, sterilized and shipped to ACUA by AUA.
   b. ACUA personnel removes the used filter cartridges and replaces with new. Cartridges are shipped with leaf samples.
5. All plant tissue and aerosol samples will be shipped to the AUA on the same day in a cooler box.

Figure 8: Leaf samples

The aforementioned guidelines also extend to any sampling of plant material that may be conducted at the replication orchards of the project in Greece and France. Any adjustments to the protocol mentioned above will be deliberated upon and sanctioned by the AUA scientists before implementation.

2.1.3 Agronomic practices at the commercial orchards

Owners of orchards allocated to the project will keep agronomic practices at their property as desired. Nevertheless, they have been asked to provide the following information to the ACUA, for better coordination of sampling activities:

a. Date, amount, type of fertilizer application.
b. Date, type, dose of copper or any other fungicide sprays.
c. Date, type, dose of insecticide sprays.
d. Any records of frost incidents.
e. Date and method (cultural, chemical) of weed management, if any.
f. Date and amount of irrigation.

The ACUA agronomist will collaborate with AUA scientists regarding sampling dates before or after pesticide sprays or weed management actions (both cultural and chemical).

The same procedures will be implemented in commercial replication orchards in Greece and France. All pertinent information will be communicated to AUA scientists in Greece and to INRAE scientists in France.

2.1.4 Agronomic practices at the higher altitude experimental orchards

The high-altitude orchards of Aeghion hold significant value for the project as they will serve as the locations for implementing the frost damage mitigation scheme with copper sprays outlined in Action C1.3. Hence, it is crucial for the success of the project to uphold the health of the trees and ensure the orchards remain in good condition throughout Action C1.3 and beyond.

AUA has drafted and provided the following guidelines for agronomic practices at these orchards to the ACUA agronomist involved in the project:

1. Irrigation network and programming has been installed and will be frequently inspected by ACUA.
2. ACUA applies fertilizer and pesticides according to AUA instructions.
3. ACUA performs weed management according to AUA instructions.
4. ACUA will replace trees damaged by frost as necessary, according to AUA instructions.
5. The ACUA agronomist will inspect the high-altitude experimental orchards twice a month. He/she will report on the condition of the orchards to the AUA and take all necessary actions to solve problems and maintain the orchards in proper condition. AUA scientists will inspect all orchards in Aeghion every 4-6 weeks.
6. Experimental sprays and sampling from the mountain orchards will be designed and carried out by AUA personnel with the assistance of ACUA personnel when needed.

The ACUA agronomist will be in close contact with AUA to relay information on the condition of the high-altitude experimental plots, to discuss and propose actions, and to receive advice on agronomic practices at these plots. ACUA is regularly monitoring the condition of these plots with onsite visits.

2.1.5 Procedure for keeping records of agronomic practices

The ACUA agronomist is responsible for communicating with the owners of the commercial orchards in this project, to record their agronomic practices. A template has been developed by AUA for maintaining records of agronomic practices across all plots. The ACUA agronomist maintains individual calendars of agronomic practices for each of the four plots, updating them as required.

The template for keeping records of agronomic practices can be found as ANNEX at the end of this document.

3 QC/QA procedures for LCS

3.1 Introduction

Low-cost sensors (LCSs) have been widely used in monitoring particulate matter (PM) mass concentrations and gaseous pollutants. These systems enable spatially dense, high temporal resolution measurements of air quality that traditional reference monitoring cannot. A major limitation of LCS is that they are not as accurate as the reference PM monitors. PM sensors used in low-cost monitors are all subject to biases and calibration dependencies, affected by operating conditions and aerosol characteristics. Maintaining the accuracy of the sensors is important and requires rigorous calibration and performance evaluation (Rayson et al., 2023; Giordano et al., 2021).

Calibration of LCSs involves determining a regression model (e.g. linear regression) that can be used to convert the measured parameter (e.g. light absorption, voltage, or conductivity) into desired output variable (e.g. pollutant/species concentration). There are two main approaches to calibrating LCSs: laboratory calibration against reference materials and field co-location with reference monitors (Kim et al., 2023; Liang 2021).

Laboratory calibration typically involves subjecting the sensor to a series of known concentrations of pollutant/species using known measurement standards in a controlled environment (Sousan et al., 2021; WMO 2020 No1215). However, this method assumes that the laboratory environment will be similar to the operating environment (e.g. using an environmental chamber to scan the typical range of temperature, humidity, pressure, etc.), which is often not the case in practice. The conditions under which sensors are calibrated in the laboratory do not often overlap with the full range of conditions encountered in an ambient environment.

Field-collocation refers to the process of operating a reference monitor or equivalent reference (eRM) and non-reference monitor (air sensor) at the same time and location under real-world conditions for a defined evaluation period (Villanueva et al., 2023; WMO 2020 No1215). Field co-location is often preferred over laboratory calibration. However, tradeoff must be made between the time dedicated to collecting calibration data and the data collected at the final measurement location. Currently, there is no standardized co-location duration, and the reported co-location durations for low-cost sensors with reference instruments in recent works have varied from several days to several months. Generally, longer co-location periods of up to several months may improve the performance of the sensors. However, optimal calibration could be produced from shorter co-location lengths if the calibration period covered the span of conditions likely to be encountered during the evaluation period (WMO 2020 No1215).

The choice of which reference method, eRM or other method is used to measure the "true" PM mass concentration is often based on practical considerations, namely which instrument is physically available where and when calibrations of low-cost PM sensors can be performed. PM regulations are based on reference methods which use gravimetric analysis of filters at a specific temperature and RH. Low-cost PM sensors would ideally have high agreement with 24-h gravimetric measurements, which are the gold-standard for regulatory uses. However, calibrating low-cost sensors with reference methods is difficult since gravimetric analysis is an off-line method that generally yields low time resolution (24-h). That means that calibrating with filter-based gravimetric reference methods can take considerably longer to both collect enough measurements over a wide range of PM concentrations. Another option is then to use equivalent reference methods (eRMs) which are used to provide higher time-resolution (typically hourly) PM mass concentrations.

The most common eRMs for LCSs calibration are the optical and electrical mobility measurements (SMPS) measurements that yield measurements of high time resolution. These methods, do not directly measure mass concentrations; rather, they estimate mass based on calibrations that convert the number size distribution into mass concentration. Methodology and Instrumentation

NCSR-D, in collaboration with MSENSIS, has developed various systems of low-cost sensors for real-time monitoring of different parameters (i.e., PM, gaseous pollutants, RH, T), tailored to specific application needs (Fetfatzis et al., 2023, 2022, 2020, 2019; Diapouli et al., 2023). As part of the LIFE FROSTDEFEND implementation, several low-cost devices were tested and calibrated before being deployed in the field for real-time monitoring of PM2.5, PM10, RH, and T. To meet the project's requirements, NCSR-D has upgraded the existing devices by incorporating additional functionalities, such as GPS and enabling power-free operation through the use of solar panels. The data acquired by these sensor systems are transferred via WiFi or SIM card and stored on a server, making them also accessible through the FROSTDEFEND web-based platform (http://live.frostdefend.eu) and the app (https://app.frostdefend.eu), where the data can be visualized and downloaded.

Figure 9: Low-cost sensors, operated with solar panels, are installed at the DEM station for calibration purposes.

Additionally, cost-effective optical particle counters (AlphaSense opc-n3) will be installed at the selected commercial plots to provide information on the number size distribution of ambient aerosol. The working principle of Alphasense OPC-N3 is similar to an aerosol spectrometer; it measures scattering from single particles.

The Alphasense OPC-N3 uses a class 1 laser (~658 nm) to detect, size, and count particles in the size range 0.35-40 μm in 24 bins, which is translated, using the embedded algorithm, into estimated PM2.5, and PM10 mass concentrations.

3.2 Calibration Methodology

The calibration of the LCS and OPC-N3 is carried out at the suburban Demokritos station (DEM), member of GAW and part of the ACTRIS and PANACEA infrastructures (37.995° N23.816° E, at 270 m above sea level (asl)) (Figure 10). The station is located within the National Centre for Scientific Research "Demokritos" campus, a vegetated area at the foot of Mount Hymettus, about 8 km to the North east from Athens city centre.

Figure 10: The Demokritos Atmospheric Aerosol Measurement station in Athens, Greece, DEM (GAW, ACTRIS acronym). The maps were obtained from Google Maps (maps.google.com).

The performance of the LCS and OPC-N3 is evaluated through co-location reference instruments (i.e. gravimetric PM samplers) and/or equivalent reference monitors (optical particle sizers). Specifically, 24 h $PM_{2.5}$ and PM_{10} samples were collected by low-volume reference samplers (Sequential 47/50-CD, Sven Leckel GmbH, Berlin, Germany) at a flow rate of 2.3 m3/h on Teflon filters and were analyzed gravimetrically for the determination of PM mass concentrations, according to EN12341. Additionally, at the DEM station numerous optical particle counters/laser aerosol spectrometers (OPS) are operated for real-time monitoring of the particle number size distributions (LAS 3340A, TSI; FIDAS FROG, Palas; Optical Particle Counter, GRIMM). The number size distributions are converted into mass using the appropriate density for each size fraction. These systems have been tested and calibrated to provide equivalent results therefore they can serve as eRM (Figures 12-15).

The LAS is an optical particle counter that uses patented wide-angle optics and an intra-cavity laser to measure the size and number concentration of airborne particles. It features a monotonic response with respect to light scattering intensity in the Mie range for precise resolution. The LAS measures particle concentration in 100 nominal size bins from about 0.1 to 10 μm.

The FIDAS FROG (Palas) dust monitor simultaneously measures the environmentally relevant mass fractions PM_1, $PM_{2.5}$, PM_4, PM_{10}, and TSP, as well as the particle number and the particle size distribution within the particle size range of 0.18 – 93 μm. Fidas® Frog operates with a volume flow of 1.4 l/min and is equipped with sensors for environmental conditions, temperature, atmospheric pressure, and relative humidity. The actual aerosol sensor is an optical aerosol spectrometer that determines the particle size using Lorenz-Mie scattered light analysis of single particles. The single particles move through an optically differentiated measurement volume that is homogeneously illuminated with white light. Each particle generates a scattered light impulse detected at an angle of 85° to 95° degrees. The particle number is measured based on the number of scattered light impulses. The level of the scattered light impulse is a measure of the particle size diameter.

GRIMM optical particle sizer measures the size-resolved number concentration per cubic centimetre of particles in the size range of 0.3 to 20 microns (optical). The instrument operates at a flow rate of 1.2 lpm. GRIMM OPCs have a very basic design principle: particles are sampled into the instrument and traverse perpendicular to a laser beam. All Grimm laser aerosol spectrometers and dust monitors use a laser diode as light source. A detector set off-axis from the laser and particle beam then records scattering intensity signals from individual particles. These are then processed to give a total number concentration and a size-number distribution. The measuring principle is the light scattering of single particles with a semiconductor laser as light source. Inside the measuring cell the scattering light is being led directly and via a mirror with a wide opening angle onto the detector. The detector is positioned in the right angle to the incident laser beam. This setup of the detector is denominated as 90° scattering light detection. This optical alignment increases the scattering light collected by the detector and optimizes the signal-to-noise ratio. Therefore, even very small particles down to 0.25 μm respectively 0.3

μm can be detected. The optical setup moreover abrades the MIE scattering undulations caused by monochromatic illumination as it is typical for laser light scattering spectrometers and therefore enables a definite particle sizing. If a particle crosses the laser beam, it creates a light pulse. The signal of the detector diode will be classified into different size channels after accordant amplification. This way the particle size distribution can be measured which provides the basis for the calculation of the dust mass.

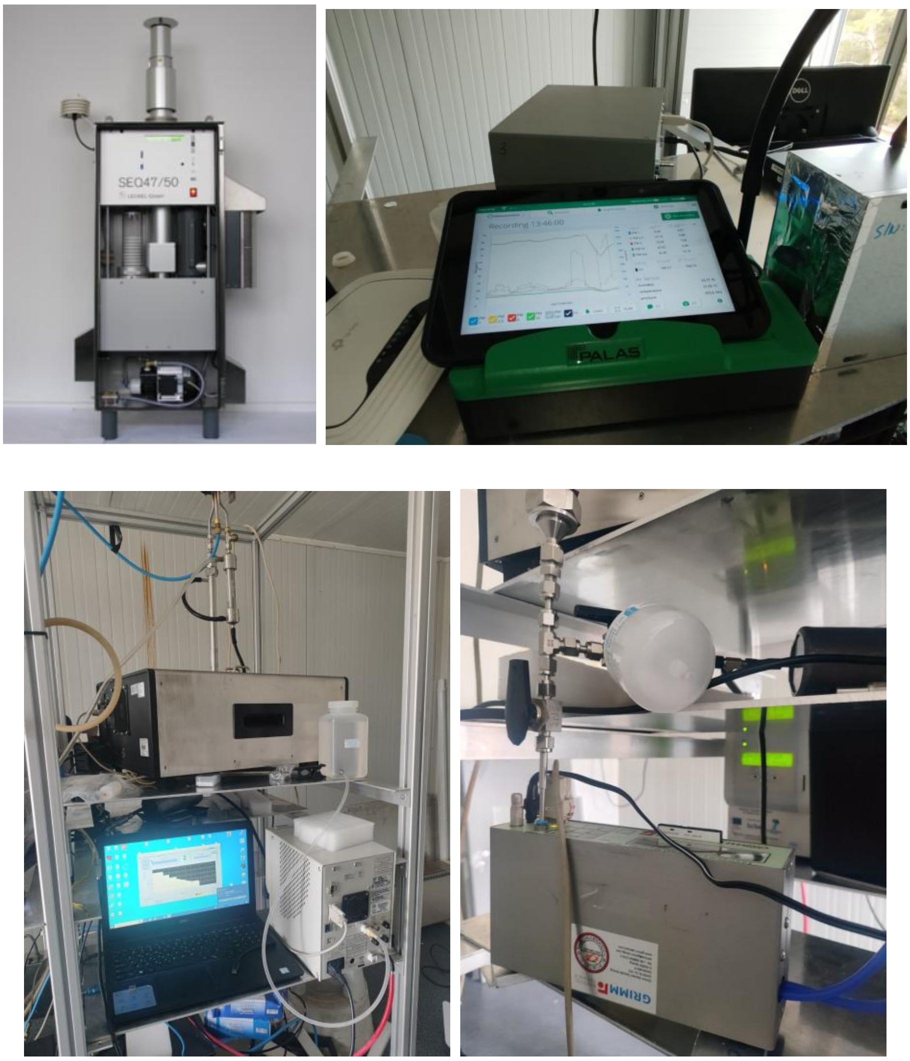
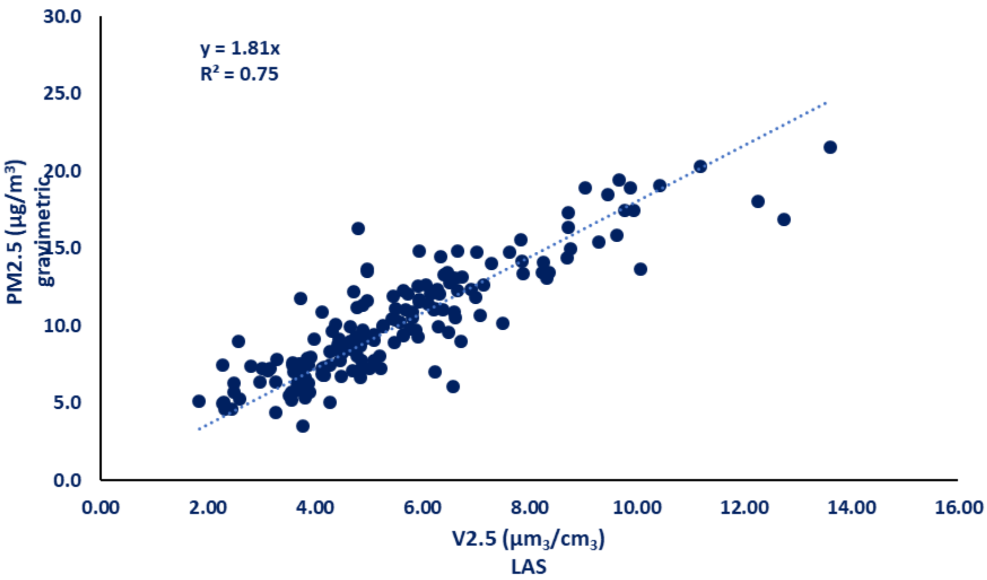


Figure 11: a) PM10 and PM2,5 standard reference sampler (Sven Leckel), b) FIDAS FROG dust monitor, c) Laser Aerosol Spectrometer (LAS, TSI) and d) GRIMM optical particle counter

Figure 12 shows the strong linear correlation between $PM_{2.5}$ and PM_{10} mass concentration from gravimetric analysis and the respective volume concentrations ($V_{2.5}$ and V_{10}) calculated from the number size distributions from LAS. The slope corresponds to the particle density.



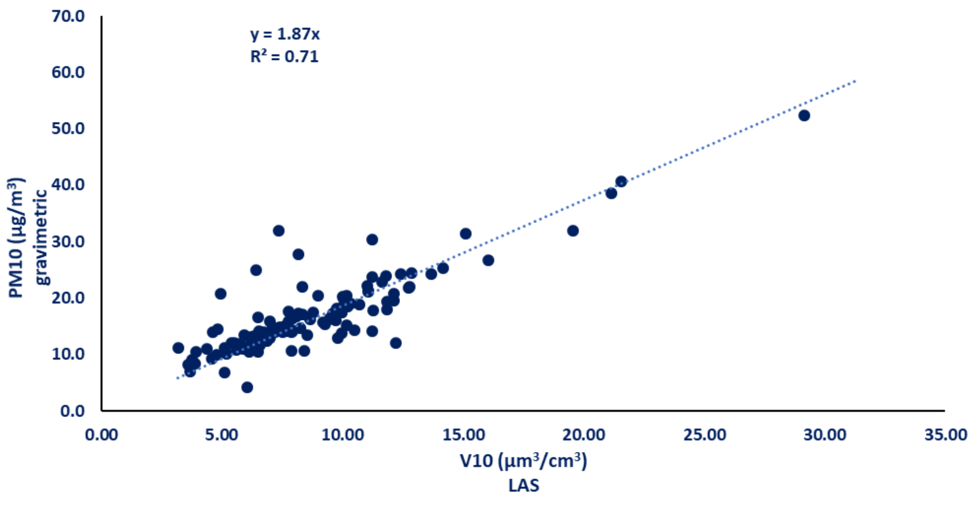
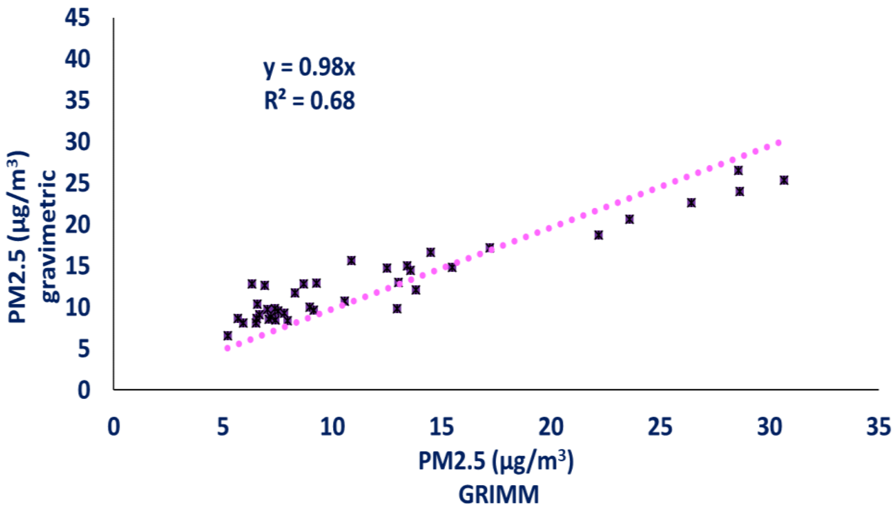


Figure 12: Comparison between calculated $V_{2.5}$ and V_{10} (24hr average) from LAS and reference $PM_{2.5}$ and PM_{10} (gravimetric analysis), respectively. The slope represents the aerosol density.



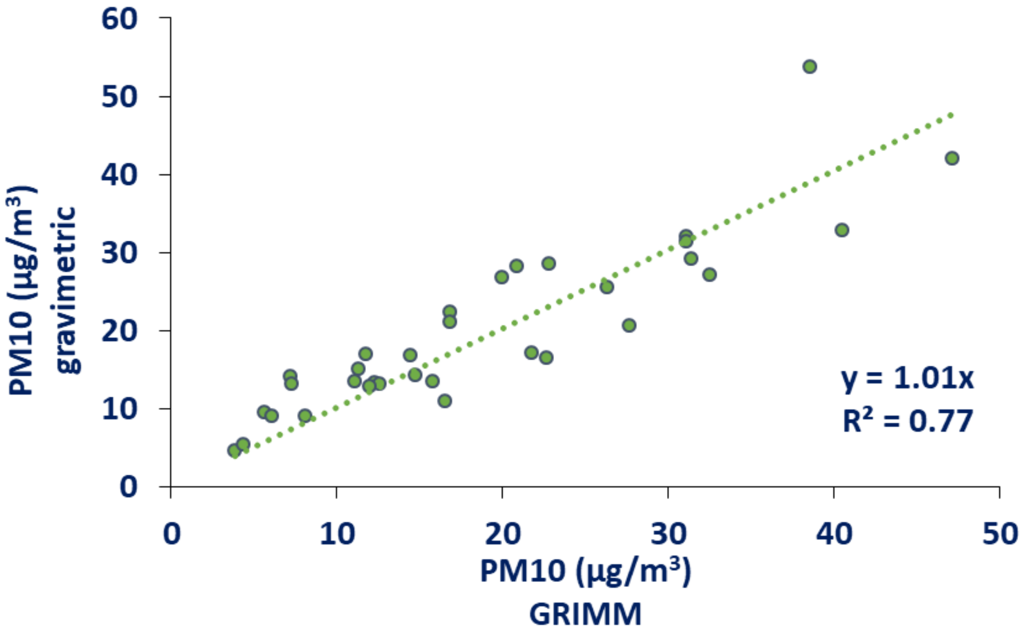
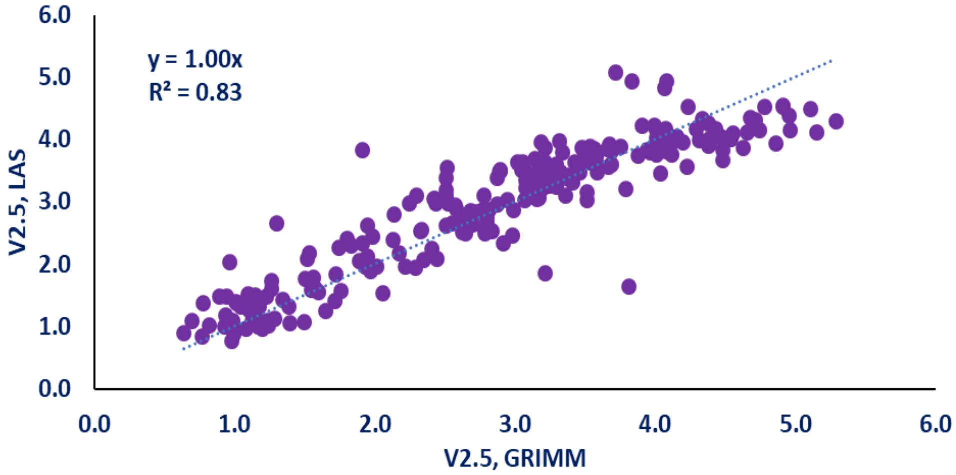
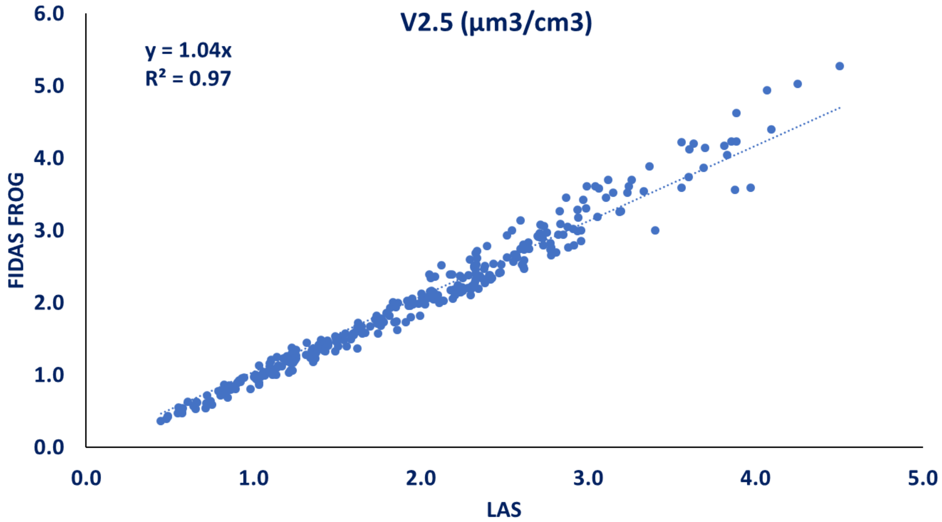


Figure 13: Comparison between calculated V2.5 and V10 (24hr average) from GRIMM and reference PM2.5 and PM10 (gravimetric analysis), respectively.


y = 1.00x
R² = 0.83
V2.5, LAS
V2.5, GRIMM
0.0
1.0
2.0
3.0
4.0
5.0
6.0


V2.5 (μm3/cm3)
y = 1.04x
R² = 0.97
FIDAS FROG
LAS
0.0
1.0
2.0
3.0
4.0
5.0
6.0

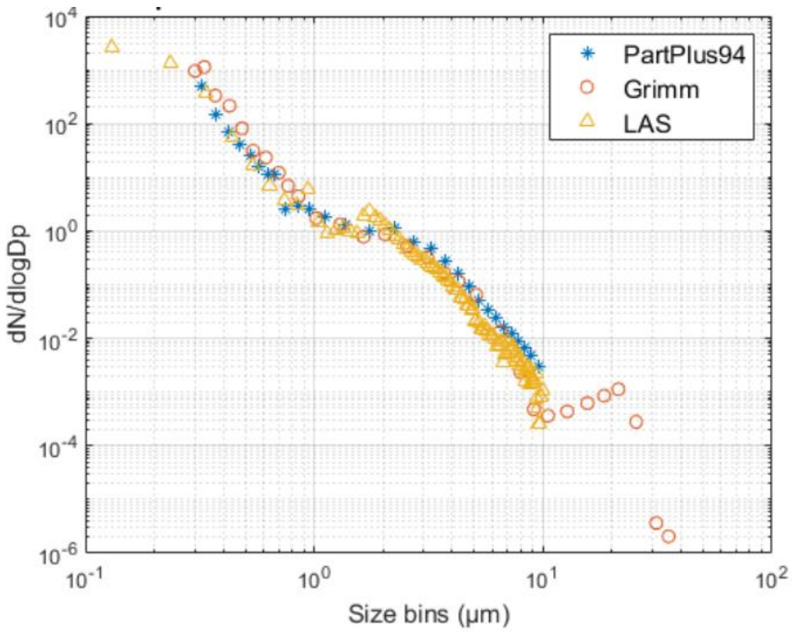


Figure 14: Comparison between V2.5 (1hr average) calculated from a) GRIMM and LAS number size distributions, b) FIDAS FROG and LAS number size distributions and c) average number size distributions between LAS and GRIMM.

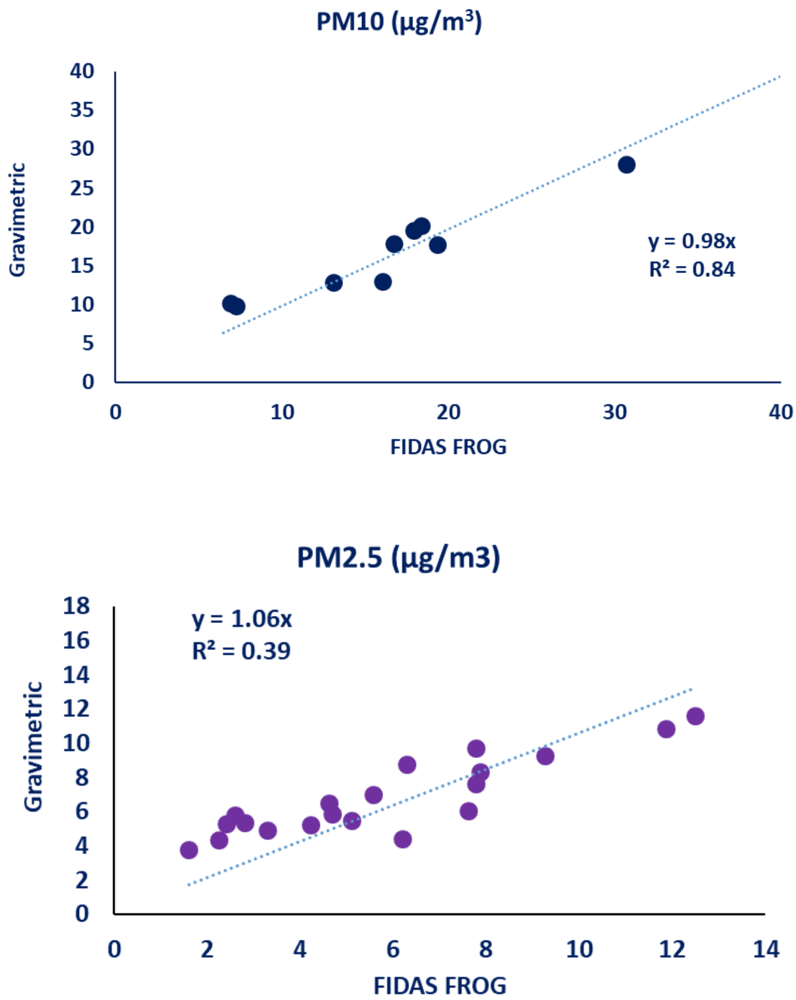


Figure 15: Correlation between a) PM10 from FIDAS FROG and PM10 gravimetric (24hr average), and b) PM2.5 from FIDAS FROSG and PM2.5 gravimetric (24hr average).

3.3 Results and Discussion

3.3.1 Calibration of low-cost PM sensors

In order to assess the long-term stability of the LCS, one low-cost system (ID2) is consistently operated at the DEM station and serves as a 'secondary reference.' This system undergoes regular calibration against the reference sampler and equivalent reference monitors for PM mass concentration measurements. Figure 16 illustrates the correlation between the PM mass concentrations measured with the ID2 sensor and the reference PM concentrations, which are derived either from gravimetric analysis (Figure

16a) or calculated from number size distributions obtained from optical particle sizers (Figure 16b and c).

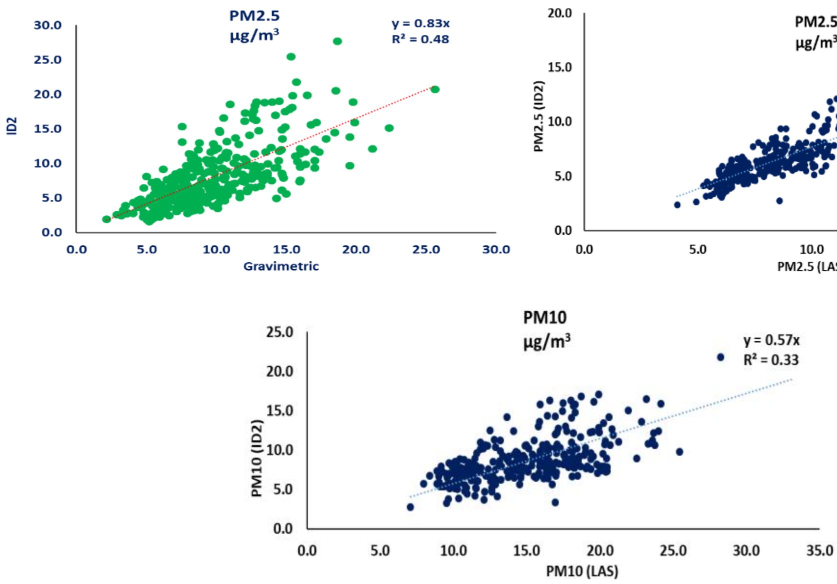


Figure 16: Correlation between a) PM2.5 from ID2 and PM2.5 gravimetric (24hr average), b) PM2.5 from ID2 and LAS (1hr average), and c) PM10 from ID2 and LAS (1hr average)

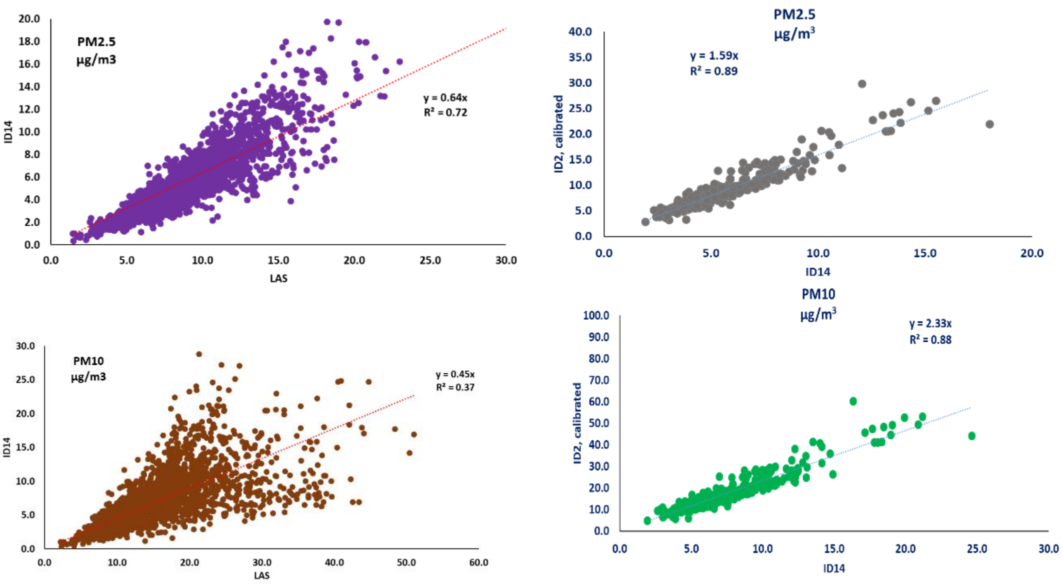


Figure 17: Correlation between a) PM2.5 and b) PM10 mass concentrations from ID14 system and OPS (LAS) (1hr average)

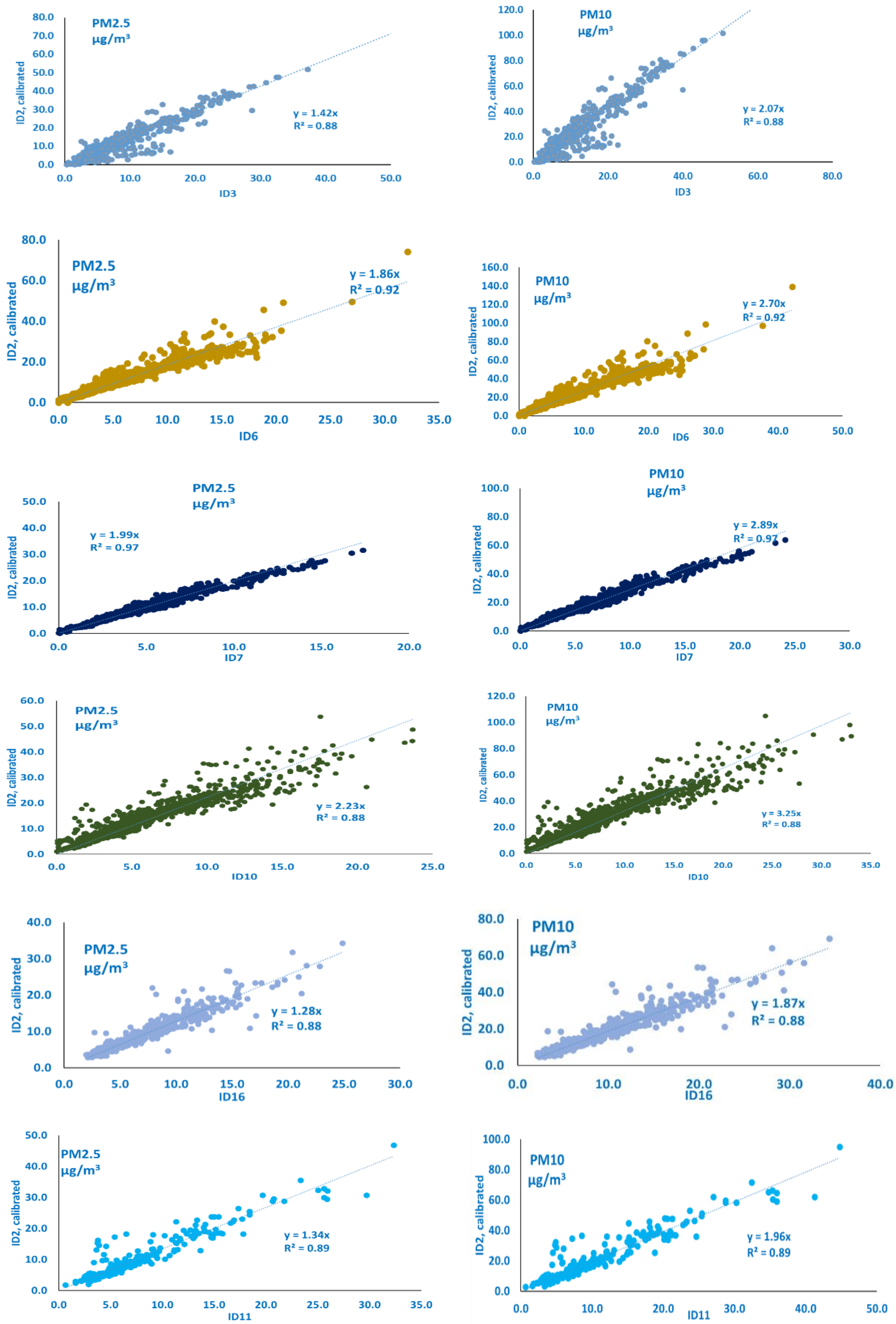


Figure 18: Correlation between ID2 (secondary reference) and ID3, ID6, ID7, ID10, ID16, and ID11 low-cost systems of sensors for PM2.5 and PM10 mass concentrations, respectively. The slope represents the calibration

factors needs to be applied the measured values (Corrected Values = CF* Measured Values).

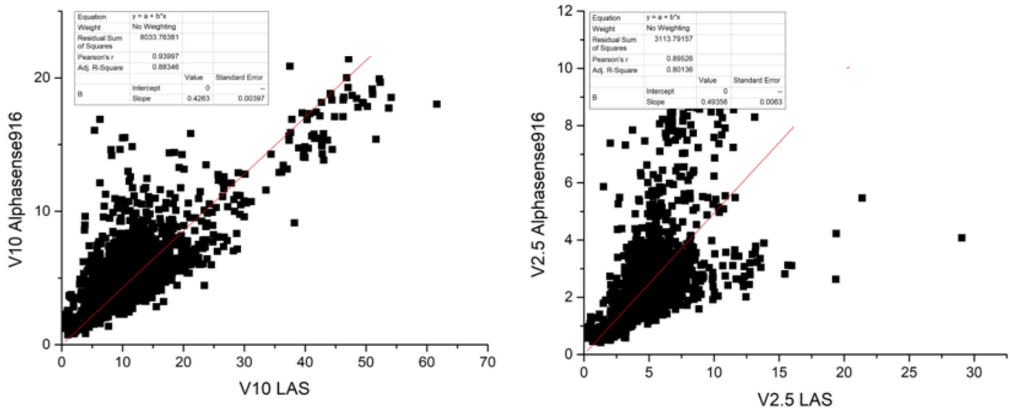
PM2.5 measured by ID2 exhibits a linear correlation with gravimetric PM2.5, characterized by a slope of 0.83 and an R-value of 0.7. Additionally, in Figure 16b and c, the correlation between PM2.5 and PM10 from ID2 LCS and those calculated from number size distributions obtained from optical particle sizers is depicted. It was observed that the ID2 sensor response displayed a strong correlation with the optical particle counter for both PM2.5 and PM10 mass size fractions, with correlation coefficients (R) of 0.8 and 0.6, respectively. The robust correlation between the two methods suggests that ID2 can serve as a secondary reference, offering accurate mass concentrations after applying a correction factor to the measured values.

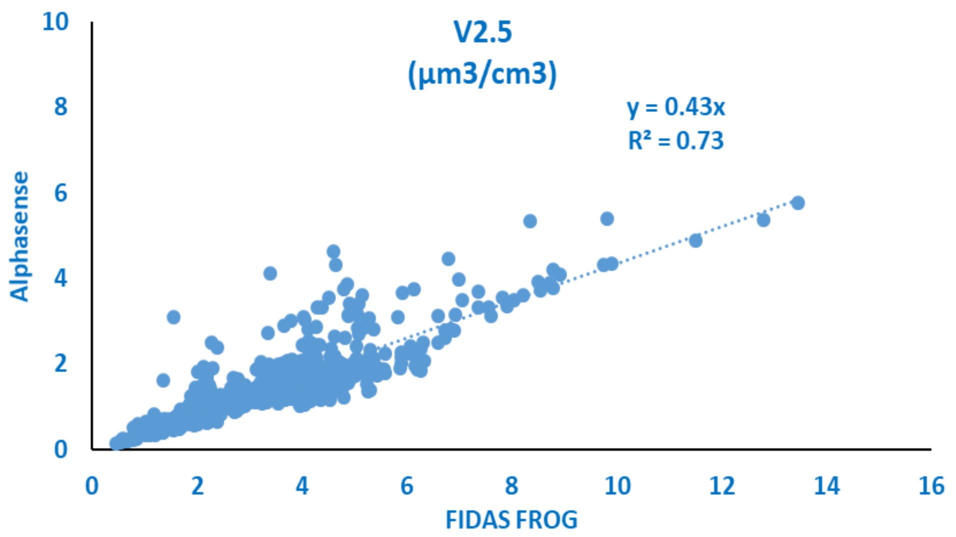
Figure 18 depicts the correlation between PM2.5 and PM10 mass concentrations obtained from various low-cost sensor systems (ID3, ID6, ID7, ID10, ID11, ID16) and the PM2.5 and PM10 mass concentrations from the secondary reference (ID2). These systems utilize the same PM sensors as ID2 but are of a different age, also featuring a slightly different design, for example, in their sampling inlets. Consequently, even though all systems display robust correlations with ID2 ($R^2 > 0.9$), a correction factor (CF) must be applied to the measured values. This correction factor is determined by the slope between the various LCS and the secondary reference.

3.3.2 Calibration of Alphasense sensors

To complement low-cost PM measurements at selected orchards and obtain a more detailed characterization of size-fractionated airborne particulate matter, especially during dust events, we conducted an initial assessment of the performance of the Alphasense OPC-N3 against reference measurements. The Alphasense OPC-N3 series is a promising cost-effective sensor for measuring particle number size distributions and mass concentrations across different size fractions. It is larger and more expensive (~$500) than many of the low-cost PM sensors (<$50) with a greater flow rate (total flow of 5.5 LPM and sample flow rate of 0.28 L/min) and a mirror that allows collection of light scattering from broader array of angles than typical low-cost PM sensors, which have flow rates on the order of 0.1 LPM (Kaur and Kelly, 2023). The OPC-N3 allows particle counting in 24-size bins for sizes ranging from 0.35-40 μm. In the framework of the FROSTDEFEND project, various OPC-N3 systems were tested and evaluated, and the results are presented in Figures 19 - 21.

As depicted in Figures 19 and 20, the Alphasense OPC-N3 sensors demonstrated a good correlation with reference measurements (FIDAS FROG and LAS). However, different correction factors have to be applied to the measured values from each system. The correction factors are determined by the slope between the V2.5 from Alphasence OPC-N3 and the V2.5 from FIDAS FROG (CF=1/slope).





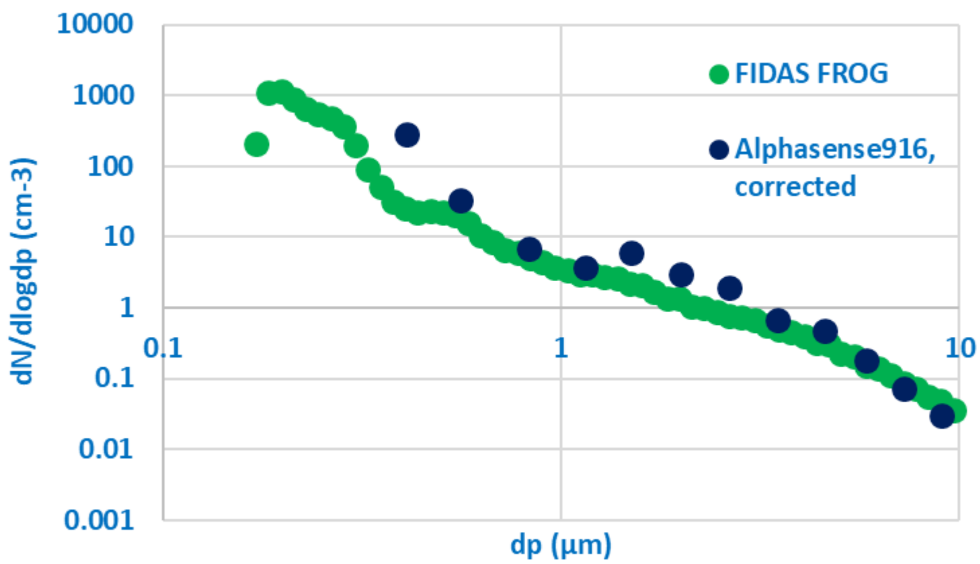


Figure 19: a) Comparison of PM2.5 mass concentration calculated from number size distributions obtained from Alphasense (ID916) and LAS. b) Comparison of PM2.5 mass concentration calculated from number size distributions obtained from Alphasense (ID916) and FIDAS FROG. c) Average number size distribution from Alphasense and FIDAS FROG

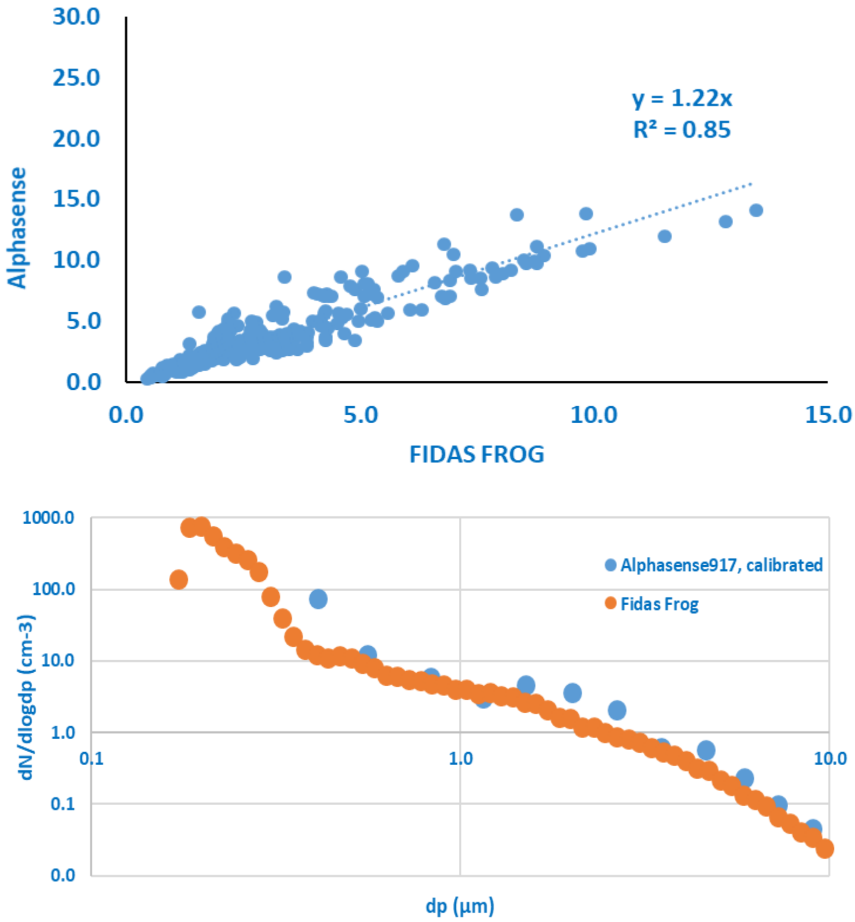


Figure 20: a) Comparison of PM2.5 mass concentration calculated from number size distributions obtained from Alphasense (ID917) and FIDAS FROG. b) Average number size distribution from Alphasense and FIDAS FROG.

3.3.3 Calibration of low-cost RH/T sensors

For the calibration of the low-cost RH/T sensors, we employed a procedure similar to that used for calibrating the low-cost PM sensors. The low-cost sensors were compared against reference instruments under field conditions. Data from our weather station (Campbell Scientific Automatic Weather Station), situated on the premises of the NCSR Demokritos campus, served as the reference. Figure 21 illustrates the results for the ID16, ID11, and ID14 sensors, demonstrating linear correlation with the reference instrument.

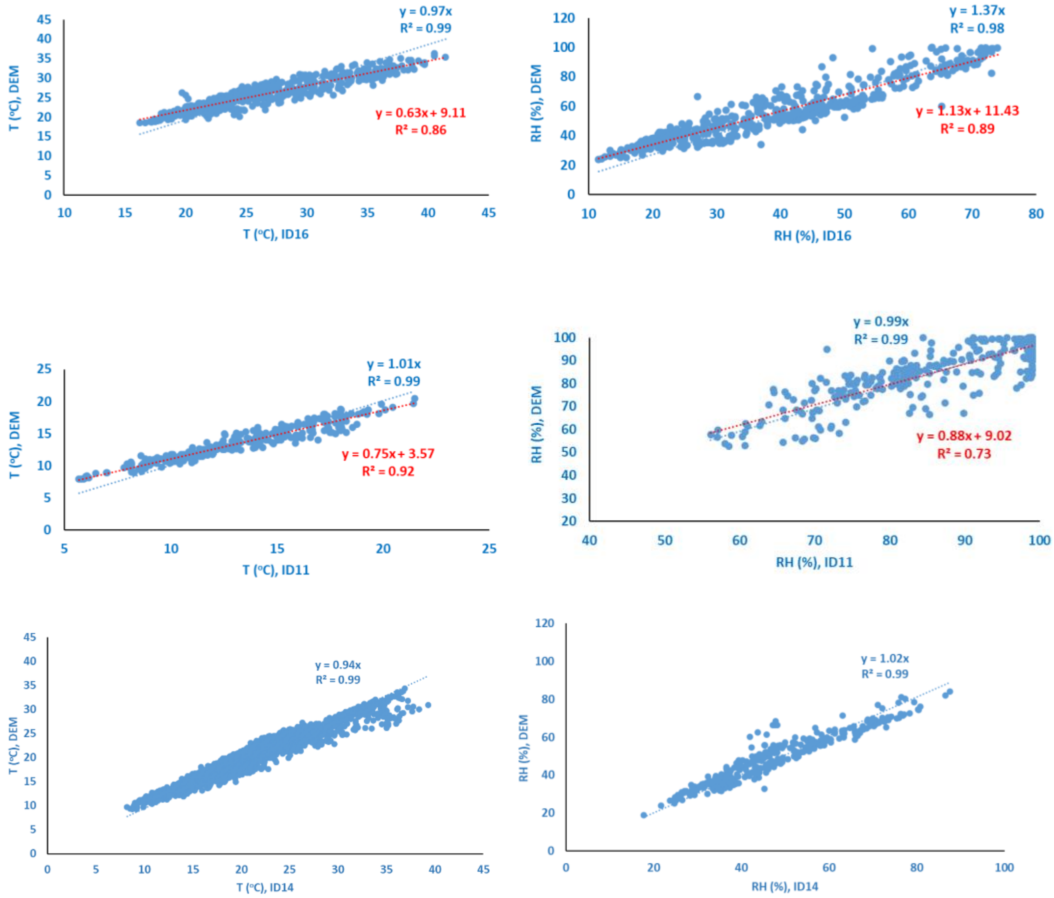


Figure 21: Correlation between reference T/RH and ID16, ID11, and ID14 low-cost systems of sensors for T and RH measurements.

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LIFE FROSTDEFEND

Year:	**2022**
Plot:	
Crop	
Owner	Mr
Life-Frostdefend contact person	

Annual Plan of Agronomic Practices

(x denotes times of replication of the action in a month)

	FERTILIZATION	IRRIGATION	FUNGICIDE	INSECTICIDE	WEED MANAGEMENT	FROST INCIDENT
JANUARY						
FEBRUARY						
MARCH						
APRIL						
MAY						
JUNE						
JULY						
AUGUST						
SEPTEMBER						
OCTOBER						
NOVEMBER						
DECEMBER						

Activity

Date

Activity

Date

Activity

Date