Abstract

The causes of air pollution range from human activities to natural events. The experimental station is capable of simultaneously monitoring and correlating data on key environmental factors. It contributes to a comprehensive understanding of the complex interaction between climate conditions, solar radiation and electromagnetic activities such as lightning. This station allows environmental monitoring to explore possible correlations and dependencies between climate parameters and solar activity and determine how storms and lightning affect the dispersion of pollutants. The station integrates advanced sensors to collect climate data, measuring temperature, humidity, atmospheric pressure, PM concentration 2.5, CO_2, NO_2, etc., solar irradiation, wind speed and direction and an electromagnetic sensor. The station can warn people in case of excessive radiation or imminent storms via a dedicated platform or SMS and will record data on a cloud service using GSM, allowing more accurate statistics and correlations. The multi-Gaussian model adapted for the study of atmospheric dispersion (Gass-DMA *) is a mathematical model that simulates the dispersion of pollutants into the atmosphere to estimate the concentration of atmospheric pollutants emitted downstream. Air pollution projections are made using complex models combining weather information and data on pollutant emissions through automatic learning. Using the OML model, we can develop a unique formula for the infrastructure of a particular region, between the location of a source of pollution and the device. This project will provide a better and deeper understanding of how solar and electromagnetic activities affect the concentration and dispersion of pollutants. Data will be collected on a very large area due to a system of stations.

Key: environmental parameters, pollutants, correlations, experimental station, sensors.

1.Introduction

Atmospheric conditions, including climate parameters and solar radiation, have a significant impact on our environment. Changes in these factors may affect ecosystems, weather patterns and large-scale human activities. Monitoring these parameters is essential for understanding and predicting environmental changes and mitigating risks. Climate data elements such as pressure, temperature and humidity help to characterise the climate in certain locations or regions.

Solar radiation, electromagnetic events such as lightning, and solar radiation influence global balance and climate, having complex effects on the environment and life on Earth, making them subject to constant study and monitoring.

2. Objectives

Determination, monitoring and analysis of all data provided by the mounted sensors, with data visualization on monitoring graphs.

Correlation study to observe the trend of evolution of the climate parameters analysed.

Developing a network of monitoring stations to integrate data analysis and improve the predictions of weather phenomena.

Test of the adapted Gaussian model - DMA * - for the study of atmospheric dispersion.

Observation of the impact of atmospheric, radiative and electromagnetic phenomena o n the dispersion of pollutants and of natural events that significantly influence emissions and t heir spread.

3. Methodology

We built two devices as a model and then we build a network out of these devices. Eac h device has a different role. This will transmit data to a cloud IoT where we can store the data . We're going to use a multi-Gaussian Math Model to simulate atmospheric dispersion. We can also create graphs and whirlwind, so that we can view the data and analyze it.

First device

The experimental device contains an Arduino MKR1010 plate, a dust sensor that detec ts PM 2,5 and PM 10, a BME680 sensor that can determine the concentration of volatile organ ic compounds and a MICS6814 sensor, which can measure the concentration of atmospheric g ases such as CO, NH3 and NO2. A pyranometer attached to the device measures solar irradiati on. All data is transmitted via WiFi to a IoT cloud using the wireless module on the Arduino p late. In addition, the device uses an SD card to store data for a longer period without requiring an Internet connection.

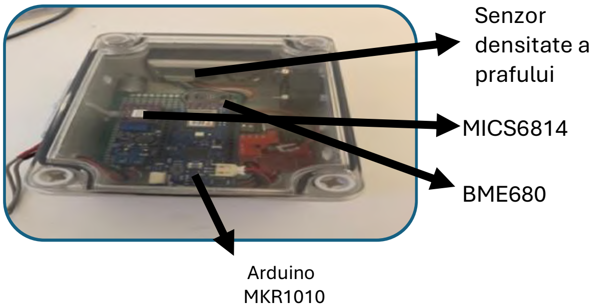


Fig.1 (first device)

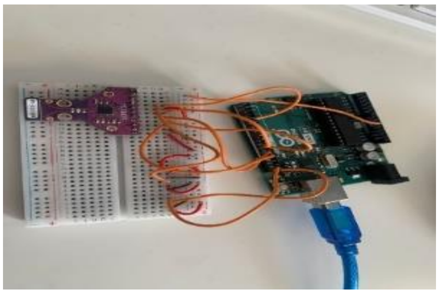
Second device

The experimental device includes temperature and humidity sensors (DHT22), pressu re (BM180), wind speed (anemometer), wind direction (wind palette) and an electromagnetic / lightning activity sensor (AS3935). The Arduino plate will also be connected to a 20x4 LC D module using the I2C interface, which will display all data as well as a SIM800L 2.0 modu le that communicates via the UART interface. This module will be able to send SMS messag es and record data in databases such as cloud IoT services,

utilizând o cartelă SIM.

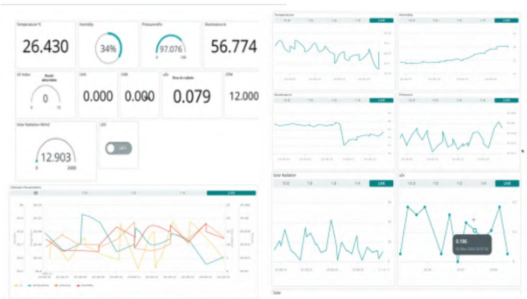
(Fig.2. Al doilea dispozitiv)

The AS3935 module is a programmable sensor that detects lightning by capturing electromagnetic signals (spherics) using an inductive antenna. It estimates the distance of the storm, detects lightning within a 40 km radius and filters electromagnetic noise. The sensor calculates the distance to lightning using the delay time between signal detection and peak voltage.



4. Data View

Data transmission is made via WiFi or GSM by devices. The data transmitted is continuously recorded in our cloud IoT system, providing a robust platform for data analysis and management. Long term data storage is possible, allowing direct integration into the processing software. The station may also send alerts in case of abnormal activity or storm detection.



(Fig.4. Cloud IoT panel) (Fig.5. Announcement messages) (Fig.6. LCD interface when lightning is detected)

5. Model Oml-multi

The OML-Multi model is a Gaussian atmospheric dispersion model used to assess air pollution from point and linear sources. It can be applied up to 20 km of sources. OML-Multi is a modern Gaussian feather model, offering an improved scaling of the boundary layer compared to older models. The OML-Multi model was developed by Aarhus University in Denmark. The dispersion equation based on the Gaussian model, which underpins the OML model, is given by the following formula:

$$C = \frac{Q}{u\sigma_z(2\pi)^{1/2}} \cdot e^{-\frac{y^2}{2\sigma_y^2}} . [e^{-(H_r-H_e)^2/2\sigma_z^2} + e^{-(H_r+H_e)^2/2\sigma_z^2}] (1)$$

Where:

C: concentrations of the pollutant in the three directions of propagation x, y, z (ppb, ppm or other units);

Q: pollutant emission rate (g / s);

us: Average wind speed at the emission point (m / s);

σy: Standard deviation of horizontal emission distribution (m);

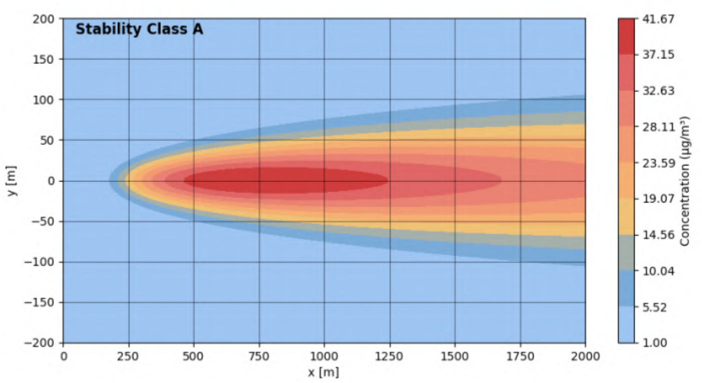
σz: Standard deviation of vertical distribution of emission (m).

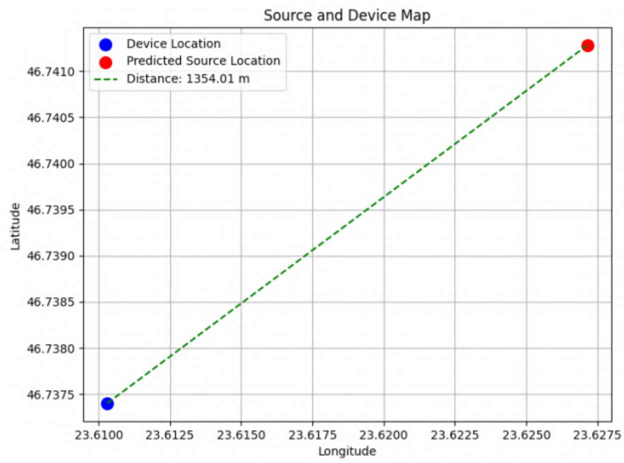
The model simulates the spatial and temporal evolution of the emitted particles, taking into ac count atmospheric conditions, soil parameters and emission rates. It provides results such as c oncentration curves, wind rosettes and pollutant dispersion maps. We integrated this mathemat ical model into an automatic learning algorithm to simulate the dispersion of pollutants under different conditions, such as storms. The algorithm is also capable of predicting the distance to a source of pollution. The source prediction algorithm shall be based on the formulae:

Source _ Lat

$$=a1 \cdot Device\_Lat + a2 \cdot Device\_Long + bSource\_Lat = a1 \cdot Device\_Lat + a2 \cdot Device\_Long + b$$

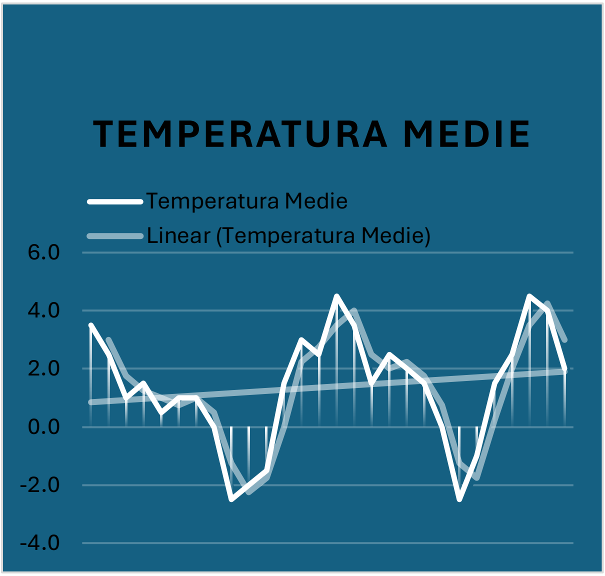
$$Source\_Long = c1 \cdot Device\_Lat + c2 \cdot Device\_Long + dSource\_Long = c1 \cdot Device\_Lat + c2 \cdot Device\_Long + d$$



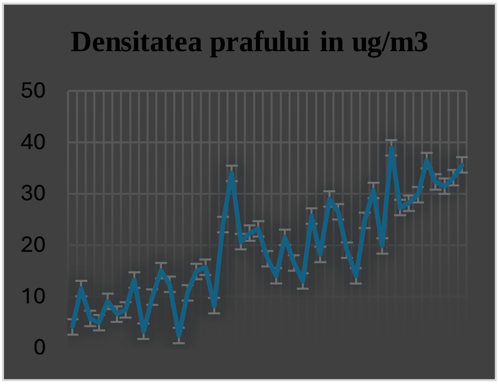


(Figure 7. PM dispersion 2.5, stability class A)   (Fig.8. source forecasting model)

6.Results



(Fig.10. concentration graph P.M. 2.5)

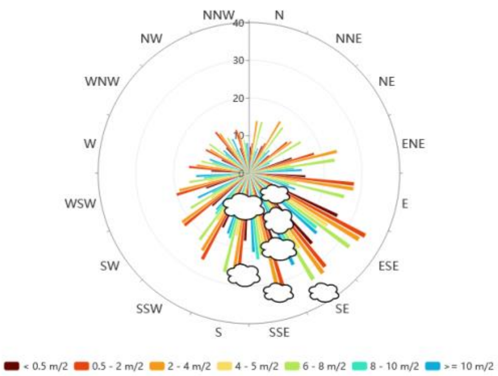


Average temperature chart in January. This is an example of a graph; graphics can be created with other data over extended periods.

(Fig.9. January temperature graph)

Fields	**Solar Irradiation**	***Temperature***	***Humidity***	***Illuminance***
Solar Irradiation	1			
Temperature	0,88	1		
Humidity	-0,92	-0,96	1	
Illuminance	0,75	0,69	-0,70	1

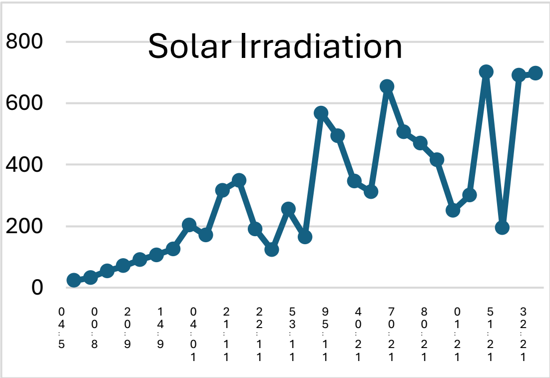
Table with correlation coefficients between parameter values - created in Excel. Functional dependencies between temperature, humidity and sunlight may be observed.



Wind rosette with every lightning record. The correlation between the proximity of the storm and the speed and direction of the wind can be observed. An imminent storm can be detected very easily.

(Fig.11. wind / lightning rosette)

The graph highlights the radiation at sunrise, peaks at noon, and cloud-related decreases. Using this data, we simulated the movement of clouds over our city.

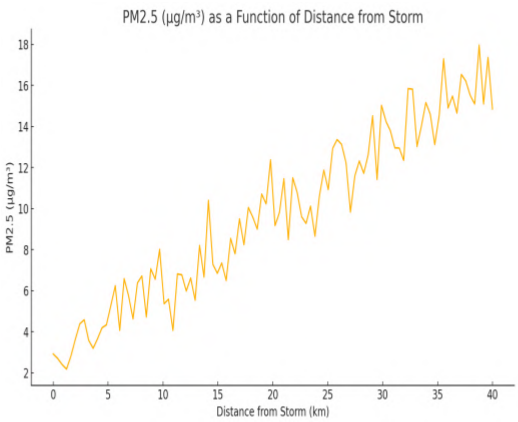


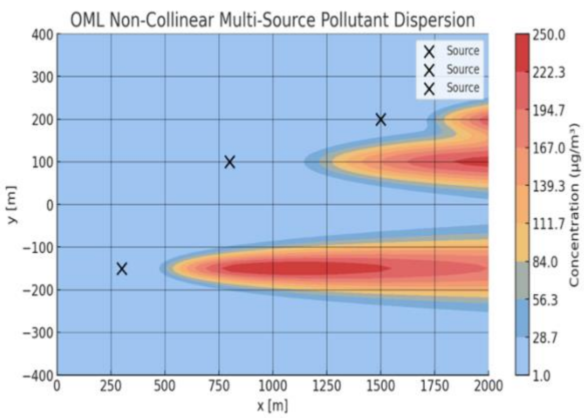
(Fig12. Solar irradiation chart). (Fig. 13 Simulation moving clouds)

Example of concentration and dispersion analysis of a pollutant depending on lightning storms and solar irradiation: P.M. 2.5

It can be observed that the concentration of P.M. 2.5 is inversely proportional to thunder storms. It can be observed that the concentration of the pollutant increases as the storm is further away and decreases with the number of lightning. The water particles in the atmosphere scatter the dust particles, which may be the cause of the drop in concentration.

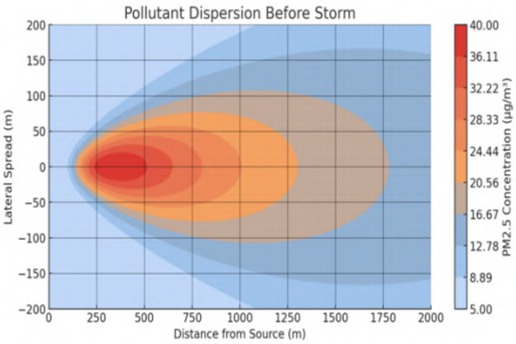
Instead, NO2 has a positive correlation with rain. Lightning interacts with the atmosphere and creates radical OH, which chemically reacts with atmospheric nitrogen to create NO2. I characterized the atmospheric dispersion of PM 2.5 during a storm. Winds disperse particles and therefore the high concentration is gathered near the source. There is also a simulation of the dispersion of NO2 caused by 3 lightning bolts, which creates quite large values.

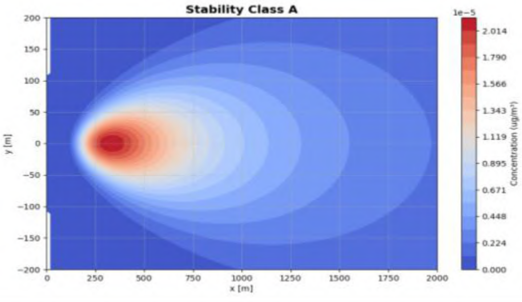


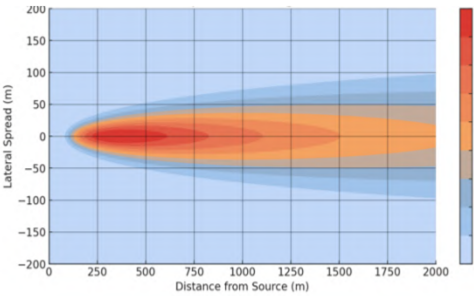


(Fig. 14. Concentration P.M.2.5 / Storm distance) (Fig. 15. Dispersion of NO2 from 3 lightning bolts)

You can see the effect of storms on a source of pollutants. The first image is the dispersion of pollutants before the storm, the second during the storm and the third after the storm. Even though the wind is strong during a storm, water particles disperse PM 2.5 so strongly that values are very low.

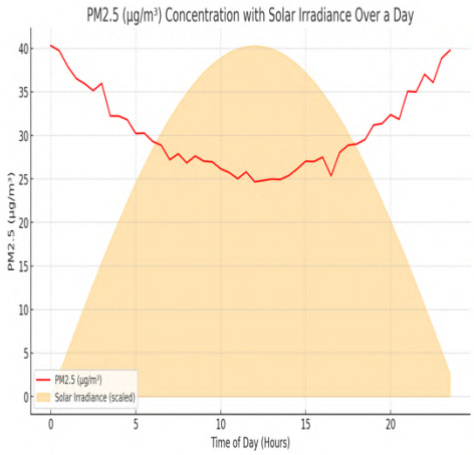


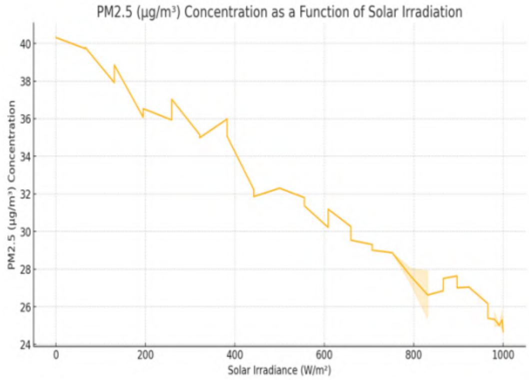




(Fig. 16. Dispersion P.M. 2.5 before the storm) (Fig. 17. Dispersion P.M. 2.5 during the storm) (Fig. 18. Dispersion P.M. 2.5 after the storm)

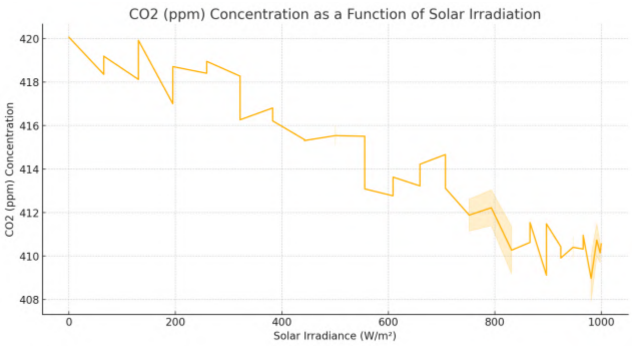
Impact of solar irradiation on particle concentration:

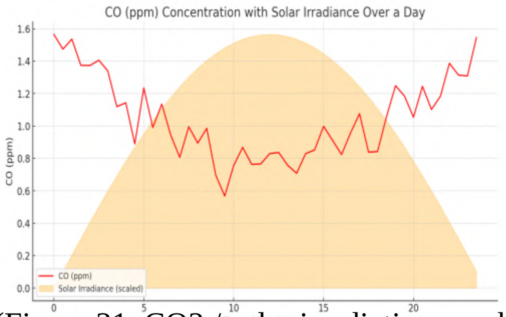




(Figure 19. P.M. 2.5 viewed according to solar radiation) (Figure 20. P.M. 25graph PM 2.5 / solar irradiation)

Contrary to previous trends, all concentrations of pollutants are inversely proportional to solar radiation. This is due to the convection effect caused by sunlight. The air warms up and the particles rise up into the atmosphere. That's why CO2 concentrations are higher at night. Some lighter compounds do not follow this trend, such as CH4. The two graphs represent this. At noon, when solar radiation is the most powerful, the concentration of particles decreases and the night rises. This decrease is due to the creation of convection as the temperature rises. Solar rays heat P.M. 2.5 and they rise up in the upper layers of the asmosphere. This applies to all particles in the air.





(Figure 21. CO2 / solar irradiation graph)
(Figure 22. CO viewed according to solar irradiation)

We can carry out such analyses for any pollutant and draw clearer conclusions.

7. Conclusions

The key parameters monitored include temperature, humidity, atmospheric pressure, solar radiation and electromagnetic activity. The station supports correlation studies to understand interactions between climate conditions and solar and electromagnetic activity. The station improves public safety by issuing severe weather warnings and high levels of radiation, increasing awareness of environmental problems.

Continuous analysis and visualisation of data aims to improve understanding of climate dynamics by supporting informed decisions in meteorology and environmental management. The project highlights the importance of accurate data for efficient atmospheric dispersion patterns, in particular the multi-Gaussian model, which is essential for correctly predicting the behaviour of pollutants according to weather conditions, geographical location and emission parameters.

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