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STAȚIE EXPERIMENTALĂ DE MONITORIZARE A PARAMETRILOR CLIMATICI ȘI A SPECTRULUI RADIOACTIV

EXPERIMENTAL STATION FOR MONITORING CLIMATIC PARAMETERS AND RADIATIVE SPECTRUM

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Abstract: *This project aims to develop a versatile tool capable of simultaneously measuring key environmental factors and making data correlations. In doing so, it seeks to contribute to a comprehensive understanding of the complicated interaction between climate conditions and solar radiation. The station integrates advanced sensors to capture essential climate data, measuring temperature, humidity, atmospheric pressure, UV index, illuminance, radiation dose and solar irradiation. Simultaneously, he uses a Geiger muller tube and a pyranometer to capture a wide spectrum of radiation. This station allows environmental monitoring, exploring potential correlations and dependencies between climate parameters and solar activity and radioactive activity. The station can warn people if they are exposed to too high doses of radiation and will record the data on a cloud service using GSM for us to make more accurate statistics and correlations.*
Keywords: *experimental device; climatic parameter; sensors; solar radiation, correlations;*

1. Introduction

The Earth's atmosphere is a complex and interconnected system that plays a vital role in supporting life. One of the key factors influencing our environment is atmospheric conditions. Changes in climate parameters and solar radiation can have far-reaching effects on ecosystems, weather patterns and human activities. Monitoring these parameters is essential for understanding and predicting environmental changes, as well as for making decisions to mitigate potential risks.

Warning on changes and dynamic activities of solar irradiation can increase human productivity, eradicate weather forecasting errors and prevent solar storms or excessive radiative exposures.

A climate data element is a measured parameter that helps specify the climate of a particular location or region, such as pressure, temperature, and humidity.

Atmospheric radioactivity and solar radiation influence the global balance and climate, having complex effects on the environment and life on Earth, being subjects of constant study and monitoring.

2. Objectives

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

Testing specific sensors, using Arduino, to be able to determine different climatic parameters, for example: pressure, temperature, humidity, solar radiation to determine and make correlations.

Correlation study to see the evolution trend of the analyzed climate parameters.

Warning in case of strong solar activities and abnormal radioactive conditions.

3. The motivation of the project

At the local community level, information related to weather and meteorology as well as climatic parameters are subjects of great interest from the perspective of everyday activities, but also as influencing factors of thermal comfort and productivity.

We want to develop a network of monitoring stations, integrating the analyzed data into a wider system and monitor solar activities over a larger area, which would result in a more accurate prediction of impending phenomena.

Atmospheric radioactivity and solar radiation influence the global balance and climate, having complex effects on the environment and life on Earth, being subjects of constant study and monitoring.

Solar radiation can directly influence the concentration of atmospheric gases and climate parameters by heating the atmosphere, changing air circulation and distributing moisture in various regions, essential phenomena for climate and meteorology.

4.1 Experimental station-technological innovation

The experimental station will contain sensors for: temperature, humidity and pressure, UV index, UVA, UVB, illuminance (integrated environmental shield), solar irradiation (pyranometer) and radiation dose (Geiger-Muller tube). The mentioned sensors will be connected to an Arduino GSM1400 board, which will process all the information read from the sensors. The board has a built-in SIM module that can communicate via GSM. This board will send the data to a cloud service that can store the data and make statistics with it. We also tested a dust density sensor and a MICS6814 sensor that can detect NO_2, NH_3 and CO.

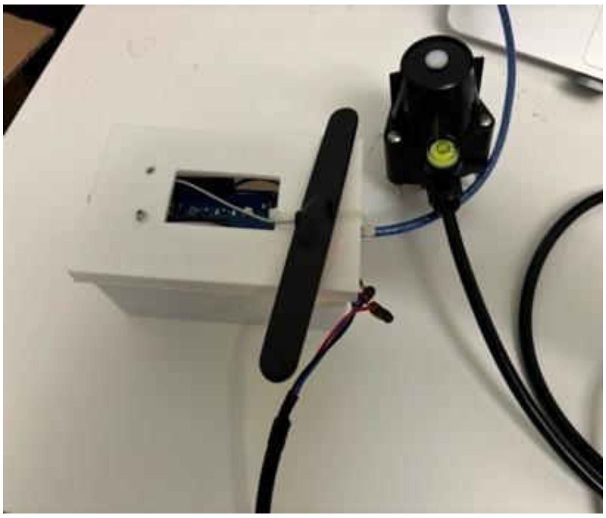


Fig. 1. The experimental station

Fig. 2. The experimental station without cover

A list of all the components

Fig. 3. The Arduino MKR1400 board

Fig. 4. The enviromental shield

Fig. 5. The Geiger counter

Fig. 6. The pyranometer

4.2 The components

The enviromental sensors

We took a mkr environmental rev 2 shield and modified it to fit our research. The shield's robust design ensures durability and reliability in various settings, making it ideal for research, monitoring, and environmental control applications. Our shield features a suite of sensors including a temperature sensor (TMP117), humidity sensor (HTS221), air pressure sensor (LPS22HB), light intensity sensor (TSL2591), and UV index sensor (VEML6075). These sensors collectively provide comprehensive environmental data, enabling precise monitoring of temperature, humidity, air pressure, light intensity, and UV index. This robust array of sensors ensures accurate environmental analysis and facilitates real-time adjustments to optimize environmental conditions for various applications in scientific research, climate studies, and environmental monitoring initiatives.

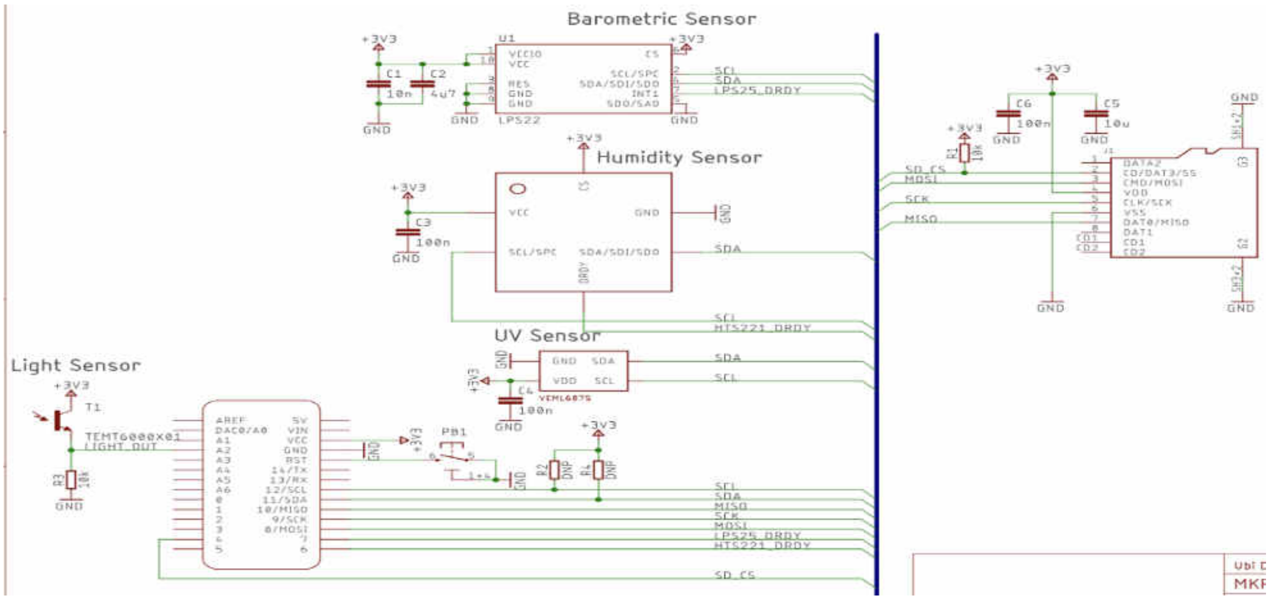


Fig. 7. Circuit diagram of the shield

The Pyranometer

The Pyranometer, an essential instrument in meteorology and solar energy studies, measures the total solar radiation received on a horizontal surface within a wave-length of 1100-400 nm. Equipped with a sensitive thermopile sensor, it precisely detects incoming solar radiation across the entire solar spectrum, including ultraviolet (UV), visible, and infrared wavelengths. This data enables accurate assessment of solar energy availability, helping to optimize solar energy systems, understand climate patterns, and assess environmental impacts. The Pyranometer's reliable performance and wide-ranging applications make it indispensable for researchers, meteorologists, renewable energy engineers, and environmental scientists worldwide.

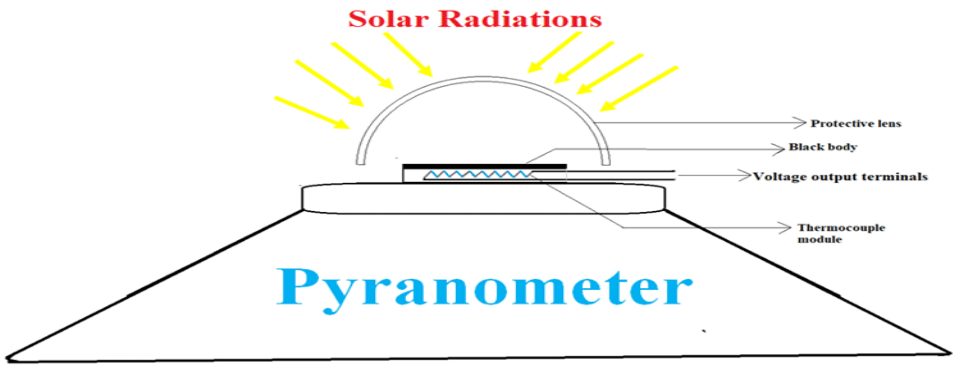


Fig. 8. Pyranometer diagram

The Geiger-Muller Counter

Our custom-assembled Geiger-Muller counter integrates the highly sensitive M4011 tube for precise radiation detection. This station detects ionizing radiation such as alpha, beta, and gamma particles, providing accurate measurements of radiation levels in various environments. Equipped with a Geiger-Muller tube, the counter efficiently detects and amplifies radiation pulses, converting them into electrical signals for analysis. With its compact design and high sensitivity, our Geiger-Muller counter is ideal for radiation monitoring, environmental surveys, laboratory experiments, and nuclear safety applications. Its versatility and reliability make it an invaluable tool for radiation detection and monitoring in diverse settings.

uSv=avgCounts151×60×(integratingTime1000)

Where: avgCounts-avgCounts is the total counts accumulated during the integrating time; Multiplier-multiplier is the scaling factor applied to convert counts to counts per minute (CPM); 151.0-151.0 is the conversion factor from CPM to microsieverts per minute; integratingTime-integratingTime is the time period over which counts are accumulated (in milliseconds). To convert it into seconds, we divide by 1000.

How does the Geiger counter work?

The Geiger-Muller counter detects ionizing radiation by utilizing the Geiger-Muller tube, a key component that contains gas at low pressure. When ionizing radiation interacts with the gas in the tube, it ionizes the gas atoms, creating a brief conductive path. This allows an electric discharge to flow through the gas, which is then detected as an electrical pulse.

Ionization of Gas: When ionizing radiation interacts with the gas in the tube, it creates ion pairs. The average number of ion pairs created per unit length of the path of the radiation (linear energy transfer) is given by the formula:

Number of Ion Pairs=Fluence Rate×Stopping Power

Where: Fluence Rate-Fluence Rate is the rate at which radiation particles pass through a unit area; Stopping Power-Stopping Power is the energy loss of the radiation per unit length in the gas.

Electric Discharge: When an ion pair is formed, it initiates an electric discharge in the gas, producing an electrical pulse. The number of pulses detected per unit time (count rate) is related to the number of ion pairs created and can be expressed as:

Count Rate=Number of Ion Pairs×Gas Amplification Factor

Where:

Gas Amplification Factor- Gas Amplification Factor is the factor by which the ionization produced by radiation is amplified due to the electric field within the tube;

Conversion to Counts per Minute (CPM):

The count rate can be converted to counts per minute (CPM) using appropriate time units:

CPM=Count Rate×60Time period

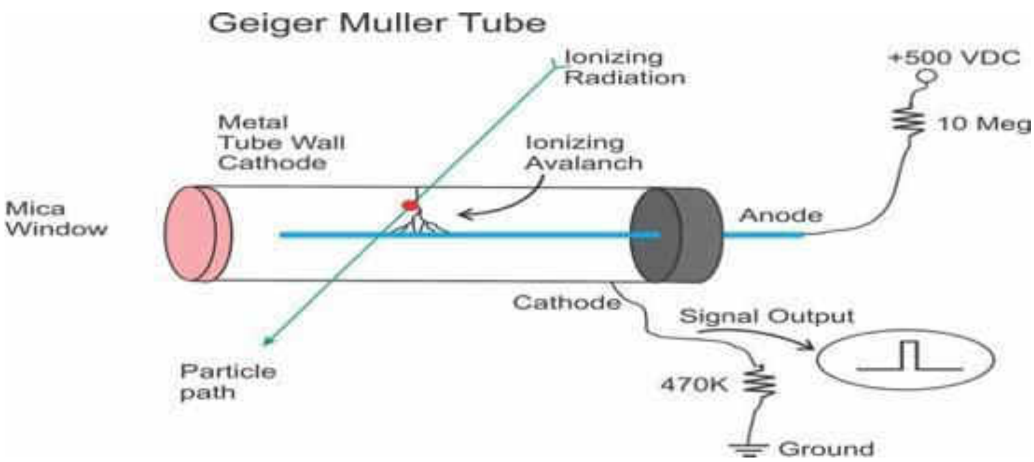


Fig. 9. Geiger-Muller tube diagram

5. How we transmit and store data?

The MKR 1400 GSM board integrates an SIM module for seamless data transmission via GSM technology at 3GHz. This ensures reliable communication across environments, with data integrated into an IoT cloud system for analysis and management. Advanced functionalities like generating graphs and storing data enable meaningful insights and historical analysis for up to a year. Real-time monitoring allows users to track station performance, identify issues, and troubleshoot remotely, enhancing operational efficiency for IoT applications.

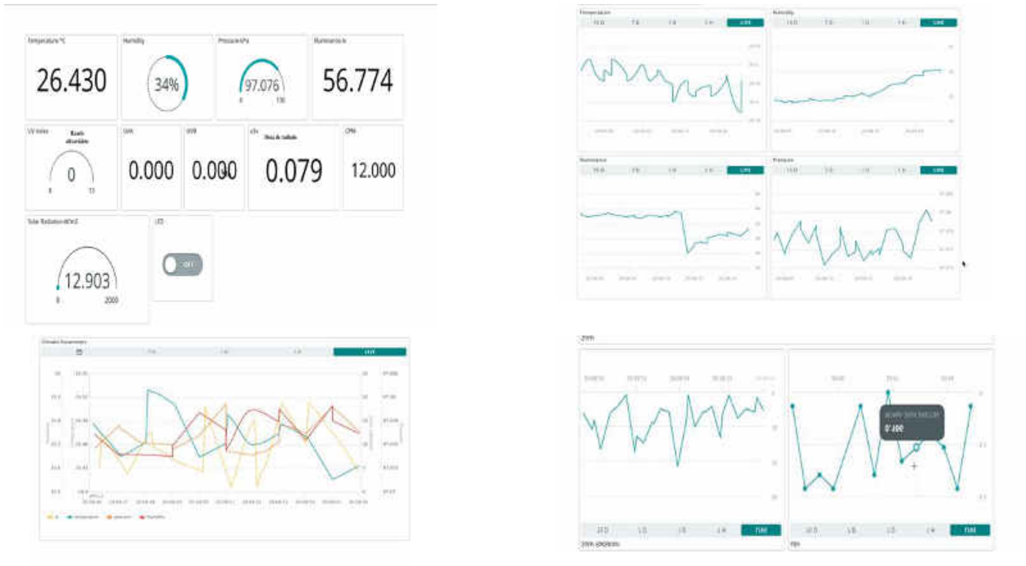
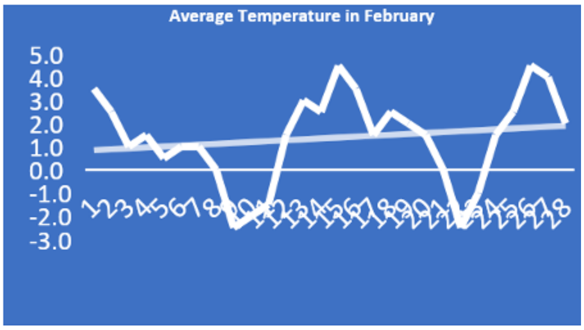
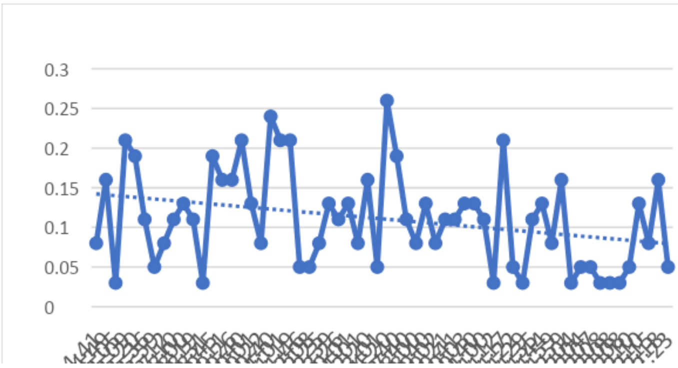


Fig. 10. IoT cloud dashboard

1. Data output



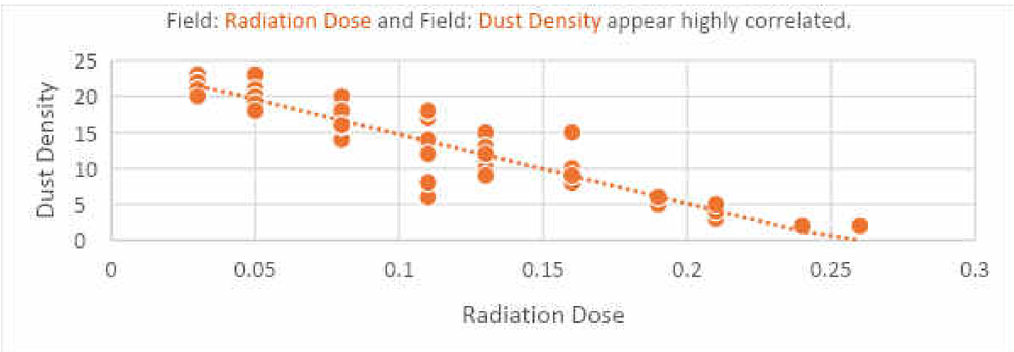


This is an example of a graph with data recorded over a month we can made using our station. It is also a graph about the radiation dose in uSv over a period of one day. The linear function shows us that the trend of the values is decreasing.

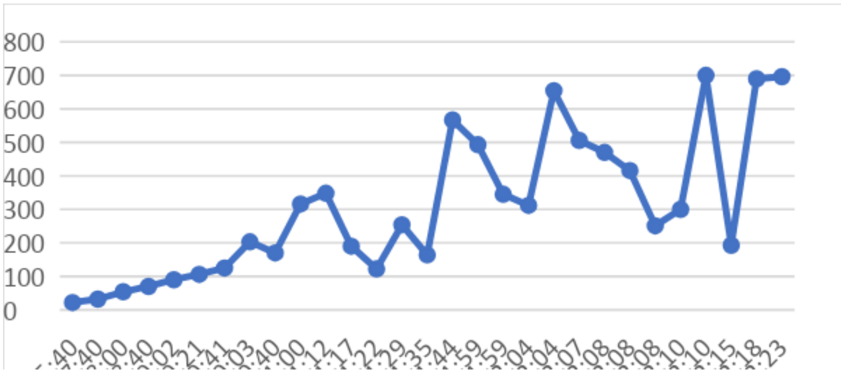
Fields	**Solar Irradiation**	*Temperature*	*Humidity*	*Illuminance*
Solar Irradiation	1			
Temperature	0,88	1		
Humidity	-0,92	-0,96	1	
Illuminance	0,75	0,69	-0,70	1

Temperature, humidity, illuminance and solar radiation are correlated with the correlation coefficients that the table contains. This correlation is given by the earth's rotation, which allows a certain amount of radiation to enter the atmosphere, affecting the temperature and lighting. The temperature in turn affects the relative humidity of the air.

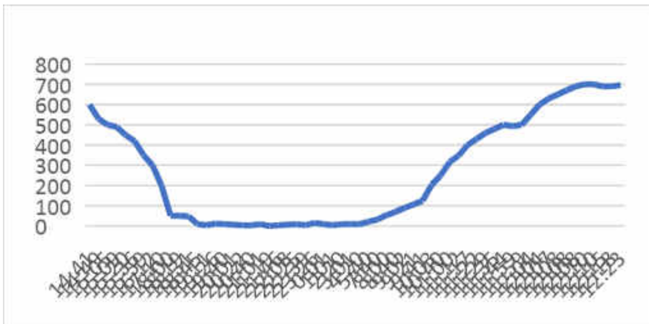
Dust density and radiation dose are correlated with a correlation coefficient of -0.94.

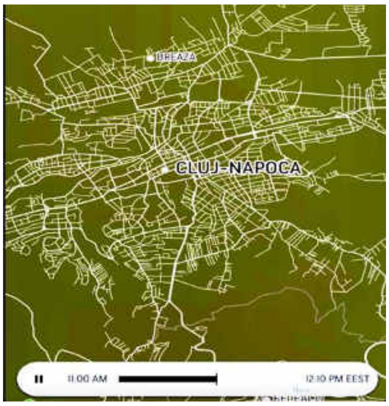


There are several reasons for this correlation: Heavier and denser particulate matter, like lead-containing dust, can act as a direct shield against radiation, reducing the amount of radiation that reaches individuals behind the shielding material. Additionally, particulate matter in the atmosphere can scatter or absorb radiation, leading to a reduction in the effective dose reaching a specific area or person. However, in environments where particulate matter is contaminated with radioactive materials but is not effectively transported or dispersed, the impact on radiation dose can be indirect and depends on factors such as proximity, exposure duration, and behavior.



The graph on the left represents the solar radiation in W/m^2 reaching the earth's surface in one day. On the right you can see the solar radiation from sunrise to approximately 8 o'clock and the peak of the radiation at 12 o'clock. The sudden drops are caused by the passing of the clouds. With these data, the decreases in radiation, the decrease in radiation, we can monitor the movement and density of the clouds. We managed to simulate the movement of clouds over our city.





All the data were recorded in the months of February, March and April of 2024 at the coordinates Latitude: 46.7657, Longitude: 23.5943. All the data that have been used:
https://drive.google.com/drive/folders/1STUHeTOh8Nm4sjNzZ43qK89HsvrRt1gt?usp=share_link

7. Conclusions

This project introduces an innovative experimental station designed to monitor and analyze key environmental parameters, including temperature, humidity, atmospheric pressure, solar radiation, and radioactive activity. By integrating advanced sensors and utilizing the MKR 1400 GSM board for data transmission, the station offers real-time monitoring capabilities and facilitates remote troubleshooting. The project's objectives encompass not only data collection but also correlation studies to better understand the complex interactions between climate conditions and solar activity. Moreover, the station serves a practical purpose by issuing warnings for severe weather events and high radiation levels, contributing to public safety and environmental awareness. Through continuous data analysis and visualization, this project aims to enhance our understanding of climate dynamics and support informed decision-making in various fields, from meteorology to environmental management. Overall, this experimental station represents a significant step forward in environmental monitoring technology, offering comprehensive solutions for data collection, analysis, and risk mitigation.

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