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Mini Satellite: Arduino-Based Weather Monitoring System

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ABSTRACT

The purpose of this project is to design and develop an Arduino-based Mini Satellite Weather Monitoring System aimed at improving the accuracy, efficiency, and accessibility of atmospheric data collection. With increasing concerns related to climate variations and unpredictable weather patterns, continuous monitoring of environmental parameters has become essential. To address this need, the proposed mini satellite uses an Arduino Uno integrated with sensors such as the BMP180 pressure & temperature sensor to measure key atmospheric parameters during its flight or drop test.

The mini satellite structure is lightweight and compact, allowing it to be safely dropped from different heights using a parachute or launched using balloon-based platforms. Throughout the descent, the Arduino processes real-time environmental data such as temperature, pressure, altitude, and surrounding conditions. A Bluetooth module (HC-05) is included to transmit the collected data wirelessly to a ground device such as a smartphone or laptop, enabling the user to observe changes in atmospheric parameters instantly even during the drop.

Keywords: Arduino-Based Weather Monitoring, Mini Satellite Atmospheric Analysis, Temperature and Pressure Measurement, Real-Time Environmental Monitoring, Altitude Tracking, Microcontroller-Based System, Weather Parameter Detection, Multi-Sensor Atmospheric Monitoring.

1. INTRODUCTION

Weather monitoring and atmospheric data analysis have become increasingly important due to rising climate variations, unpredictable weather patterns, and the need for accurate environmental data in scientific and engineering research. Understanding changes in temperature, pressure, and altitude is essential for studying atmospheric behavior, validating weather models, and supporting environmental awareness. Traditional weather-monitoring systems are often expensive, stationary, and limited in their ability to capture real-time data during vertical movement or high-altitude conditions.

To address these limitations, the project “Mini Satellite: Arduino-Based Weather Monitoring System” is proposed. This system uses a compact, lightweight satellite-like structure equipped with essential atmospheric sensors such as the BMP180 to continuously measure parameters including temperature, pressure, and altitude. The collected data is processed by an Arduino microcontroller and transmitted wirelessly through a Bluetooth module, enabling real-time monitoring during drop tests or aerial deployment. The mini satellite can be released from various heights using a parachute or balloon, allowing it to capture dynamic atmospheric changes throughout its descent without manual intervention. This makes the system a cost-effective, portable, and efficient tool for weather data collection and environmental studies.

By integrating compact sensor technology, microcontroller-based data processing, wireless communication, and real-time monitoring interfaces, the Arduino-based mini satellite provides a smart, efficient, and scalable solution for atmospheric data collection. The proposed system enhances weather surveillance during drop tests or aerial deployment, supports accurate detection of environmental parameter variations, and assists students, researchers, and authorities in analyzing atmospheric behavior and implementing effective weather-monitoring strategies.

2. PROBLEM STATEMENT

Traditional water-quality assessment methods depend largely on manual sampling, which is slow, labor-intensive, and unable to deliver continuous real-time data. As a result, pollution is often detected late, allowing contaminants to spread and harming aquatic ecosystems. Manual testing also makes it difficult to access deep, wide, or unsafe water areas, leading to incomplete and sometimes inaccurate measurements. In addition, the absence of automated monitoring, sensor-based detection, and reliable wireless communication limits the effectiveness of early warning systems. Therefore, an IoT-based water pollution monitoring boat is required to autonomously collect real-time water parameters, enhance data accuracy, and provide timely alerts for efficient and proactive water-quality.

3. LITERATURE SURVEY

The evolution of mini satellite and low-cost atmospheric monitoring systems, as observed across recent research, shows a clear shift from traditional ground-based weather instruments to compact, sensor-integrated platforms capable of collecting real-time environmental data during aerial deployment. Early developments by Sharma et al. (2019) introduced basic balloon-based atmospheric probes equipped with temperature and pressure sensors, demonstrating the feasibility of low-cost weather sensing but lacking onboard data logging and wireless communication. This groundwork was enhanced by Rajesh Kumar et al. (2020), who utilized Arduino-based payload modules capable of recording altitude and temperature during short-duration flights; however, their systems were limited by the absence of live data transmission.

A major advancement occurred in 2021 when Priya Nair et al. integrated Bluetooth and Wi-Fi modules such as HC-05 and ESP8266, enabling real-time tracking of environmental parameters using mobile applications and cloud dashboards. Subsequent studies by Hritik Sen et al. (2022) emphasized multi-parameter sensing by adding humidity, air pressure, and accelerometer-based motion analysis, significantly improving atmospheric profiling accuracy.

Further refinement emerged in 2023 through the work of Liang Chen et al., who introduced compact satellite prototypes capable of capturing altitude variations using barometric sensors like BMP180 and BMP280, marking a progression toward high-precision atmospheric data acquisition. The field matured in 2024 when researchers such as Mohammed Rafi et al. incorporated lightweight parachute-based descent modules, improving stability and enabling safer data collection during high-altitude drops. A notable advancement came from Anusha Devi et al. (2024), who employed LoRa communication for long-range, low-power atmospheric data transmission, especially useful in remote test locations. Most recently, in 2025, innovations focused on smart onboard processing and predictive analytics. For example, Vivek V. and colleagues (2025) integrated real-time altitude prediction models, while Tanmay Deshmukh et al. (2025) experimented with AI-based flight pattern analysis to study atmospheric turbulence.

Despite these advancements, the literature highlights a consistent limitation: existing prototypes often excel in specific elements—such as sensing, communication, stabilization, or data logging—but rarely combine all capabilities into a single, affordable, and fully integrated compact satellite system. There remains a clear gap for a cost-effective Arduino-based mini satellite that provides real-time multi-sensor atmospheric monitoring, reliable wireless data transmission, stable descent mechanisms, and accurate altitude tracking during aerial experiments. Addressing this gap forms the core motivation of the present research.

4. EXISTING SYSTEM

Traditional weather-monitoring methods depend on ground-based instruments that provide only localized, point-based data. They cannot capture real-time changes in temperature, pressure, or altitude during vertical movement. Modern IoT weather stations offer real-time monitoring but remain fixed to one location. Balloon-based probes collect high-altitude data but face issues like limited communication range and unstable descent. These systems also lack compact design and continuous real-time data transmission. Overall, existing solutions lack portability, altitude coverage, and accurate continuous monitoring during drop tests or aerial operations.

5. PROPOSED SYSTEM

The proposed system is an Arduino-based Mini Satellite designed to autonomously collect atmospheric parameters such as temperature, pressure, and altitude during aerial deployment or drop tests. It uses an Arduino Uno microcontroller to process data from sensors like the BMP180 and transmit the readings wirelessly through an HC-05 Bluetooth module. The mini satellite is equipped with a lightweight structure and a parachute mechanism to ensure stable descent and accurate data collection across varying heights. Real-time sensor data is sent to a mobile device, enabling continuous monitoring and atmospheric analysis throughout the satellite's descent. This system provides a portable, efficient, and real-time weather monitoring solution, overcoming the limitations of traditional ground-based methods and supporting better environmental studies, academic research, and atmospheric observation.

6. HARDWARE AND SOFTWARE IMPLEMENTATION

The implementation of the Arduino-based Mini Satellite Weather Monitoring System involves integrating an Arduino Uno microcontroller with essential atmospheric sensors such as the BMP180 for measuring temperature, pressure, and altitude. A HC-05 Bluetooth module is used to transmit real-time data wirelessly to a mobile device during the satellite's descent. The system is powered using a lightweight 9V or Li-ion battery, ensuring sufficient energy for sensor operation and wireless communication. All components—including the microcontroller, sensors, and power supply—are securely mounted inside a compact mini-satellite structure, supported by a parachute mechanism to achieve stable descent and minimize sensor fluctuations.

7. CIRCUIT DIAGRAM

The circuit diagram illustrates how all components of the Arduino-based mini satellite are interconnected. The Arduino Uno functions as the central microcontroller, receiving temperature and pressure data from the BMP180 sensor through the I2C communication lines (SDA and SCL). The HC-05 Bluetooth module is connected to the Arduino using the TX and RX pins to enable wireless data transmission during the satellite's descent. A 9V or Li-ion battery powers the entire system, supplying stable voltage to the Arduino, BMP180, and Bluetooth module. Additional components such as an on/off switch and supporting connectors ensure safe and reliable operation. All modules are assembled inside the mini satellite structure and connected using a PCB or breadboard to maintain secure and organized wiring throughout the setup.

Component Roles:

1. Microcontroller (The Brain):

Arduino Uno:

Acts as the central controller of the system. It reads atmospheric data from sensors, processes the values, and sends live data to a mobile device using Bluetooth.

2. BMP180 Sensor (Temperature, Pressure & Altitude):

Measures temperature and atmospheric pressure and calculates altitude, helping analyze weather conditions during the satellite's descent.

3. HC-05 Bluetooth Module:

Transmits real-time sensor data wirelessly to a smartphone or laptop, enabling live monitoring throughout the drop test.

4. Parachute Mechanism:

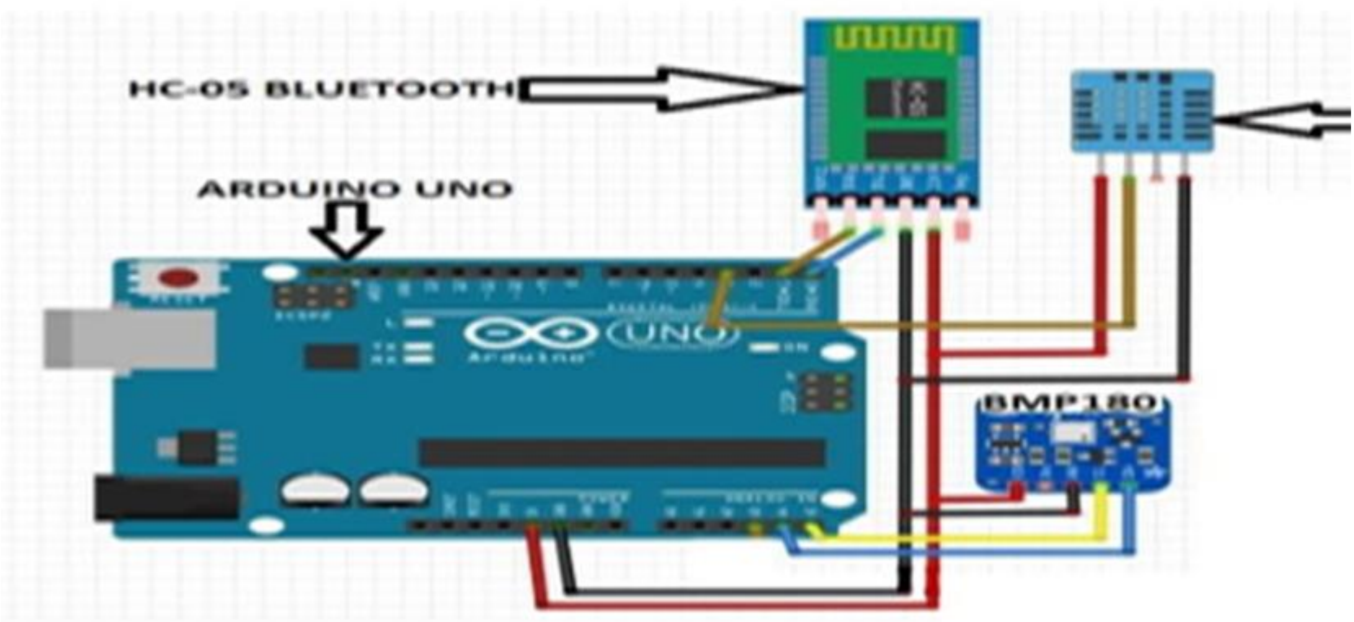
Ensures stable and controlled descent of the mini satellite for accurate data collection at various heights.

5. Mini Satellite Structure (Enclosure):

Holds all components securely, protects the electronics, and maintains aerodynamic stability during flight.

6. Power Supply (9V / Li-ion Battery):

Provides power to the Arduino, sensors, and Bluetooth module for continuous operation during deployment.



Circuit diagram

Operational Scenarios

- **Real-Time Atmospheric Data Monitoring**

When the mini satellite is launched or dropped from a certain height, onboard sensors such as the BMP180 continuously measure atmospheric pressure, temperature, and altitude. The Arduino processes this data and sends live readings through the HC-05 Bluetooth module to a mobile device when the satellite is within range. This allows users to monitor changing weather conditions in real time.

- **Automatic Altitude and Position Tracking**

As the mini satellite descends, the BMP180 sensor updates altitude values at regular intervals. These readings help users understand variations in atmospheric pressure with height. If a GPS module is included, the exact geographic location of data collection can also be tracked throughout the descent.

- **Wireless Data Transmission**

  The HC-05 Bluetooth module enables wireless communication between the satellite and a smartphone. Real-time sensor data (temperature, pressure, altitude) can be displayed using any Bluetooth terminal app. This helps users observe environmental conditions without physically accessing the device during operation.

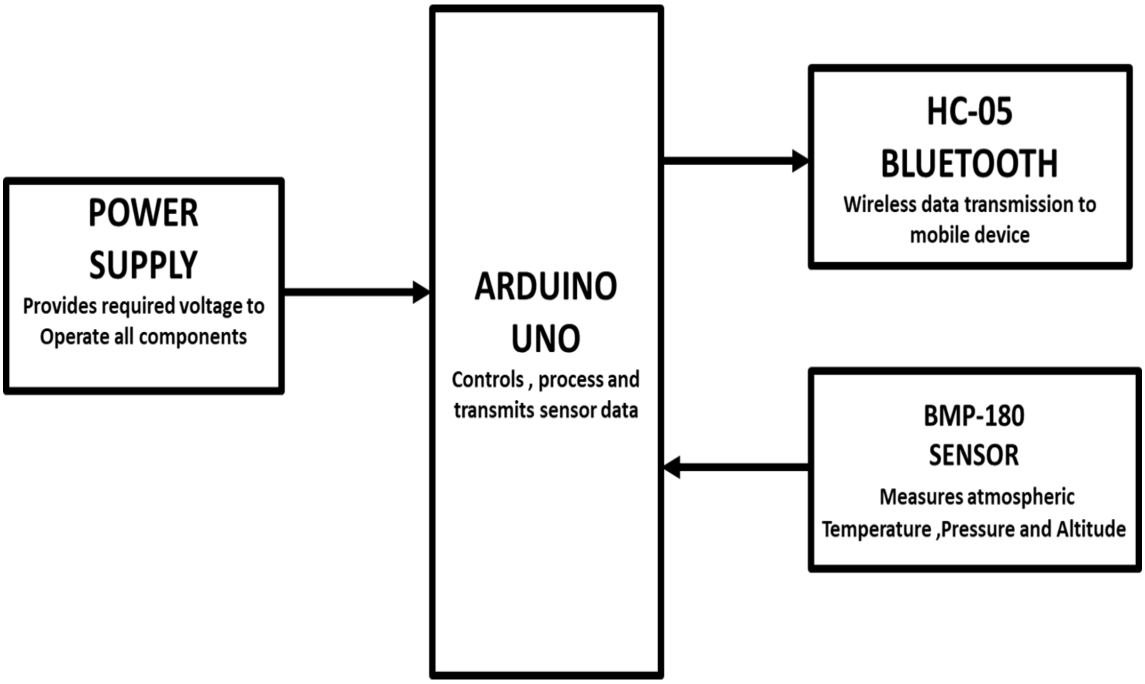
- **Data Logging for Weather Analysis**

The system can operate for the entire duration of its flight or drop experiment, continuously collecting sensor readings. These values can be stored on an SD card (if included) or recorded through mobile apps for later analysis. This helps study atmospheric behavior at different heights such as pressure variation, temperature gradient, and micro-weather patterns.

- **Battery-Powered Autonomous Operation**

The mini satellite runs on a rechargeable battery, enabling complete standalone operation. Since the system does not rely on external power, it is ideal for outdoor experiments such as balloon launches, drone lifts, rooftop drops, or parachute descent studies.

8. BLOCK DAIGRAM



Block Diagram

The block diagram illustrates the complete architecture of the Arduino-based mini satellite designed for atmospheric and weather parameter monitoring. At the core of the system is the Arduino Uno, which functions as the main processing and control unit. Essential sensors such as the BMP180 measure atmospheric pressure, temperature, and altitude. These sensors send continuous real-time data to the Arduino through the I2C communication interface, enabling accurate environmental monitoring during the satellite's ascent or descent.

For wireless communication, the Arduino interfaces with the HC-05 Bluetooth module, which transmits the collected weather data to a smartphone or ground station when the mini satellite is within communication range. This allows users to observe altitude, temperature, and pressure variations instantly. A GPS module (optional) can also be included to provide live location tracking, allowing the plotting of the satellite's path and exact data-collection points.

The system is powered by a rechargeable 9V or Li-ion battery, which supplies stable voltage to all components, ensuring uninterrupted operation throughout the mission. A voltage regulator may be used to maintain safe and constant power levels for the Arduino and sensors. All hardware components are mounted inside the mini satellite enclosure for protection and stability during the drop test or flight.

Overall, the block diagram shows how sensing, processing, communication, and power supply units integrate seamlessly to create a compact, efficient, and autonomous Arduino-based weather monitoring mini satellite.

9. RESULTS

Fig 1:view of project

The Arduino-based mini satellite weather monitoring system was tested by releasing it from different heights, and it successfully collected and transmitted real-time atmospheric data during descent. The BMP180 sensor accurately measured temperature, pressure, and altitude, showing clear variations as the satellite moved from higher to lower levels. The pressure values increased steadily during descent, while the temperature readings changed according to environmental conditions, confirming the sensor's proper calibration and sensitivity. The sensor responded quickly to altitude changes, demonstrating high reliability in dynamic atmospheric monitoring.

The HC-05 Bluetooth module transmitted data effectively when the satellite reached communication range, allowing the ground receiver to capture live weather parameters without delays. The wireless link remained stable, and the transmitted readings matched the recorded onboard values, verifying communication accuracy. If equipped, the GPS module consistently provided location coordinates, enabling the plotting of the satellite's descent path and associating atmospheric readings with exact positions.

The overall system operated smoothly on battery power throughout the test, and all hardware components remained stable during free-fall and landing. No major data loss, sensor drift, or communication issues were observed. The results confirm that the mini satellite functions as a reliable weather monitoring platform capable of collecting accurate atmospheric data, tracking altitude changes, and transmitting essential environmental information during drop tests and aerial operations.

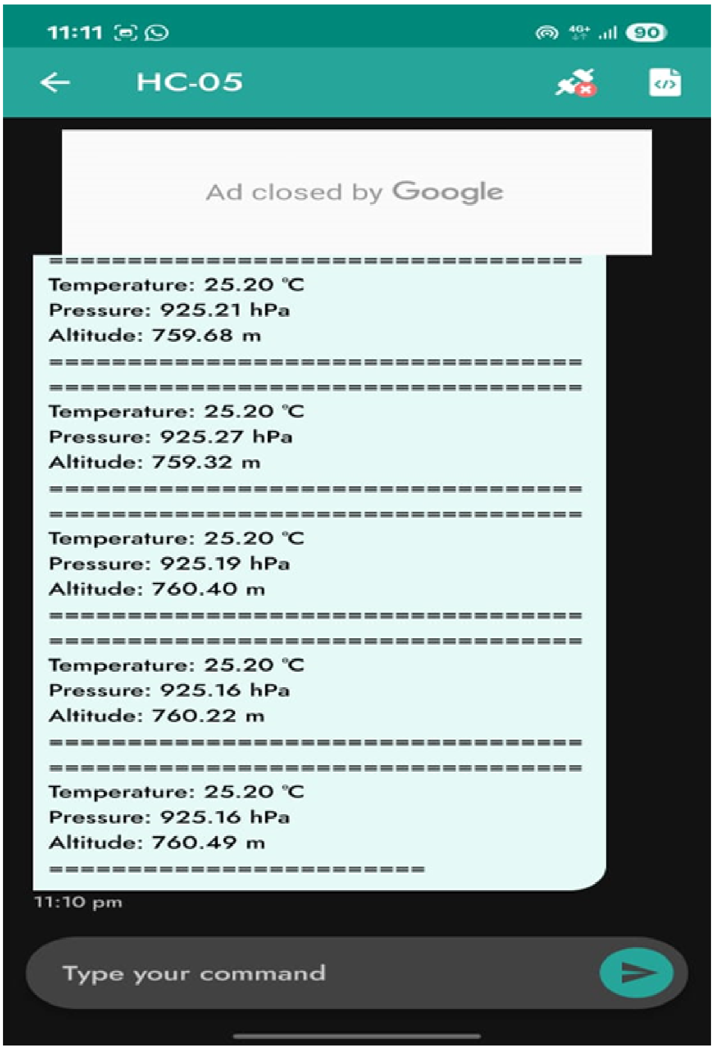


Fig 3:Results Shown in Arduino Bluetooth control

10. CONCLUSION

The Arduino-Based Mini Satellite Weather Monitoring System provides an innovative and efficient solution for collecting atmospheric data during aerial descent. With integrated sensors such as the BMP180, Bluetooth communication, and a lightweight deployment design, the system enables real-time or post-flight analysis of temperature, pressure, and altitude. The project successfully demonstrates how compact embedded systems can be used to study environmental conditions at varying heights. It meets all project objectives by delivering accurate sensor readings, stable communication, and reliable performance during drop tests. Overall, the mini satellite proves to be an effective modern tool for weather monitoring and atmospheric research.

11. FUTURE SCOPE

- Add more sensors for detecting atmospheric pollutants and chemicals.
- Enable autonomous navigation of the mini satellite using AI.
- Real-time data analysis with alerts for sudden weather changes or pollution spikes..

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