
# AgDataBox-IoT Application Development for Agrometeorogical Stations in Smart Farm

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**A paper from the Proceedings of the**
**15th International Conference on Precision Agriculture**
**June 26-29, 2022**
**Minneapolis, Minnesota, United States**

***Abstract.***

*Currently, Brazil is one of the world's largest grain producers and exporters. Brazil produced 125 million tons of soybean in the 2019/2020 growing season, becoming the world's largest soybean producer in 2020. Brazil's economic dependence on agribusiness makes investments and research necessary to increase yield and profitability. This study describes the development of a sensor network (agrometeorological station) for climate monitoring of management zones (microclimates), allowing the identification of climate factors that influence yield at each stage of crop development. For this, ten low-cost agrometeorological stations were built to monitor the climatic conditions of the management zones (five stations in each of the two previously established MZs) on a property (15-ha) in southern Brazil. For this, a computational architecture was built to develop an application called AgDataBox-IoT, which includes hardware and software divided into layers of data processing and integration. This application seeks to integrate data, procedures, software, and methodologies to provide useful information to farmers using data obtained by agrometeorological stations installed in smart farms. The low-cost agrometeorological stations that were installed allowed data collection with a low coefficient of variation (CV) indicating the accuracy of temperature sensors used, and in the 15-ha experimental area, there was no significant difference in temperature among the MZs. The results achieved are promising since the low cost of the stations installed in the experimental area, the gratuity, and ease of operation of the AgDataBox-IoT.*

***Keywords.***
*Big data, precision agriculture, networks, Internet of Things, AgDataBox.*

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## Introduction

Agriculture has already entered its 4.0 version, also known as digital agriculture, and this new paradigm uses Internet of Things (IoT) techniques, sensors installed in the field, a network of interconnected sensors in the plot, drones for crop monitoring, multispectral cameras, storage and processing of data in Cloud Computing, and Big Data techniques to process the large volumes of generated data. One of the practical options for implementing precision agriculture (that uses agriculture 4.0) is the segmentation of the plot into management zones (MZs), aiming at maximizing profits according to the productive potential of each zone, being economically viable even for small producers, since it is possible to use conventional machines for the application of inputs in this type of management technique. Considering that climate factors directly influence yield, this study aims to describe the development of a sensor network (agrometeorological station) for climate monitoring of management zones (microclimates), allowing the identification of climate factors that influence yield at each level stage of crop development. For this, a free web platform called AgDataBox (ADB, http://adb.md.utfpr.edu.br) was used to integrate data, software, procedures, and methodologies.

## AgDataBox-IoT Application

The digital platform ADB has several application programming interfaces (API) in microservices architecture (MSA), which consists of a set of resources accessible by the hypertext transfer protocol (HTTP) to transfer request and response messages expressed in JavaScript Object Notation (JSON) format. ADB-API allows the interoperability of several applications in which data and processing routines are centralized. The following applications that consume ADB-API resources are under development: 1) ADB-Mobile (android application to record facts and organize operations in the field); 2) ADB-Map (thematic maps creation and management zones delineation); 3) ADB-Admin (to manage the resources for storing platform data); 4) ADB-IoT; (5) ADB-RS (to acquiring and processing images obtained by remote sensing). This work presents ADB-IoT, a network of interconnected sensors such as those applied to MZs for the climatic and water monitoring of the plant. For this, a computational architecture was built for the ADB-IoT application development, including hardware and software, which can be divided into four layers: (i) Data acquisition layer (Agrometeorological Stations – AgDataBox-IoT), (ii) Communication and transmission layer among stations and Data server, (iii) Data server, and (iv) API (Application Programming Interface)/AgDataBox for data access. These layers were developed independently to allow interoperability with other solutions/technologies in each layer. MQTT (Message Queuing Telemetry Transport) protocol connects communication among the stations and the local server, connected with an Access Point TP-Link TL-WA721N installed at a 10-meter height in a communication tower placed on the farm. Communication between local server and server (http://adb-iot.unioeste-foz.br:3004) is carried out by REST (Representational State Transfer) client/server architecture by sending data in JSON (JavaScript Object Notation) format. Ten low-cost agrometeorological stations were built to monitor the climatic conditions of the MZs (five stations in each of the two previously established ZMs) on a property (15-ha) in southern Brazil. The agrometeorological station is composed of five main parts: (i) processing, sensor data acquisition, and data transmission unit; (ii) analog-to-digital data conversion (ADC) module, which connects up to four analog sensors; (iii) I2C module, which allows data acquisition from up to four sensors with I2C output; (iv) One-Wire module, which allows data acquisition from the sensors and has a One-Wire output; and (v) MicroSD card module, which stores the collected data, being incorporated into the project for data security if there is a lack of communication with the server. The station is powered by a DC source or solar battery system, supporting voltage from 3.3V to 28V. Considering that the internet availability in rural areas can be a limiting factor to send data to the ADB-IoT server located in the data center of Itaipu Technological Park (ITP), we decided to use computational resources close to IoT sensors for local data storage and pre-processing

(ADB-IoT Local Server). A Raspberry Pi 3 Model B was used to develop the AgDataBox-IoT Local Server. Raspberry Pi was responsible for providing pre-processing, storage, and communication close to the devices, that is, locally, acting as an MQTT (Message Queuing Telemetry Transport) broker, which used the Mosca broker (MQTT) and implemented in Node.js. As a result, the computational architecture developed, and the low-cost stations made it possible to acquire, transmit, store and process data without significant losses, except in sporadic events of severe weather events. The sensors used, for the most part, already reading their data by I2C digital interface, showed outstanding durability and accuracy on readings since none of them had defects during the project, and one of the factors that contributed was the self-calibration capacity of these sensors, which are of the state-of-the-art, reducing the need for laboratory calibration. The installed stations allowed data collection with a low coefficient of variation (CV), indicating the accuracy of temperature sensors used, and in the 15-ha experimental area, there was no significant difference in temperature among the MZs. However, in the first ten days, the stations presented the highest CV values, which decreased over time, showing the improvement of the stations.

## Conclusion

The results achieved are promising since the low cost of the stations installed in the experimental area, the gratuity, and ease of operation of the ADB-IOT make such a proposal useful for farmers to increase the performance of operations and crop productivity given the best decision that this technology will provide.

### Acknowledgments

The authors would like to thank the UNIOESTE, UTFPR, the Coordination for the Upgrading of Higher Education Personnel (CAPES), the National Council for Scientific and Technological Development (CNPq), the Itaipu Technological Park Foundation (FPTI), and the Ministry of Agriculture, Livestock and Food Supply (MAPA) for funding this project.