Meteorological station as a Big Agricultural Data Source – Technical solution proposal

Aleksandra Stojnev Ilić
Computer science
Faculty of Electronic engineering
Nis, Republic of Serbia
aleksandra@elfak.rs

Miloš Ilić, Petar Spalević
Electrical and computer engineering
Faculty of Technical Sciences
Kosovska Mitrovica, Republic of Serbia
milos.ilic@pr.ac.rs, petar.spalevic@pr.ac.rs

Mirjana Spalević
Department of Hydrometeorology and Seismology
Podgorica, Montenegro
mirjana.spalevic@meteo.co.me

Abstract— **The application of information and communication technologies in agricultural production is an area in expansion. Knowledge of relevant factors and specifics of the environment is a basic advantage in the process of agricultural production. This paper addresses problems associated with modelling of a meteorological station, and creation of big meteorological datasets. In addition, the paper describes the advantages of using big data in the process of agricultural production. Monitoring of meteorological changes on the field is conditioned by the distance of the closest meteorological station, therefore problems with incomplete, missing or incorrect data may arise due to aforementioned distance. The proposed conceptual solution of meteorological station model represents an autonomous solution for remote monitoring of meteorological and spatio-temporal attributes, and it is based on the components available on the market. The efficiency of this solution is reflected in the constant monitoring of meteorological parameters using selected group of sensors. In this way we could create a system of meteorological stations that would provide big meteorological data. Such big data would be suitable for further analysis, and prediction of meteorological changes, and their impact on agricultural production.**

Keywords-Big data, meteorological station, sensors, Raspberry Pi, GSM/GPRS

I. INTRODUCTION

Agricultural producers can make decisions about future activities on production areas based on real-time monitoring of specific meteorological data. Monitoring can be carried out both by using traditional and digitized meteorological stations, and it is an example of science and technology blended together for prediction of the atmospheric state for an observed field [1]. Digitalization of meteorological data stream monitoring offers the possibility of creating big agriculture datasets, useful for various analytics in the domain of precision agriculture [2]. Depending on the predefined usage, agricultural meteorological stations should be equipped with an appropriate group of sensors. In addition to sensors for monitoring meteorological parameters (air temperature, humidity, wind speed and direction, precipitation, relative humidity, ...), agricultural meteorological stations most often are also equipped with specific sensors for monitoring parameters such as: soil moisture, humidity of leaf plants, etc.[3]. If the purpose of one meteorological station is to operate as a node in a bigger system for wide geographical area covering, it should be equipped with components for spatial and temporal attributes determination. This data is needed in base stations for spatio-temporal positioning of each received measurement.

The main goal of the conducted research was to create a proposal of agricultural meteorological station technical solution. The proposed model is intended for collection of huge amount of Big Data. Solution includes the selection of different hardware components for meteorological and spatio-temporal measurements, achieving communication between the meteorological and base station, and for achieving a permanent source of alternative power supply. The model of processing and use of big meteorological data was another goal of the conducted research.

The paper is organized as fallows: Second section represents general information of big meteorological datasets that can be used in agriculture. Third section represents overview of hardware components included in the model. Fourth section represents information about communication hardware components. Fifth section represents calculation of needed power supply. Sixth section represent main conclusions and ideas for future work.

II. BIG METEOROLOGICAL DATA IN AGRICULTURE

Meteorological data complies with 5V rule of big data: volume, velocity, variety, veracity and value. Volume is absolutely a slice of the bigger pie of Big data. The internet-mobile cycle, delivering with it a torrent of social media updates, sensor data from tools and an outburst of e-commerce, means that all industry swamped with data, which can be amazingly valuable if you understand how to work on it. The rapidly increased volume of the meteorological data is due to the rapid development in the field of sensor technologies and IoT. Increased number and availability of devices capable of generating meteorological data leads to the expansion in the volume of the collectable data. The data retrieved for example from IoT devices and meteorological stations accumulates in very high speed as it is important to create time series of data in fine time granularity in order to support different analysis algorithms. This counts as velocity of the meteorological data, and it is the measure of how fast the data is coming in. Meteorological data can be generated either by humans or by machines, and it can be structured, semi-structured or unstructured. This contributes to the variety of the meteorological data. Structured data collected in SQL tables are a matter of past. Today, 90% of data produced is 'unstructured,' arriving in all shapes and forms- from Geospatial data to tweets which can investigate for content and thought, to visual data such as photos and videos. Furthermore, meteorological data veracity refers to the assurance of quality, integrity, accuracy and credibility of the data. Since the data is collected from various sources, trusted or not, it must be checked before usage. Veracity applies to the uncertainty of the data available to marketers. This may also be referred to as the variability of data streaming that can be changeable, making it tough for organizations to respond quickly and more appropriately. However, the real value of the meteorological data is not in the collection of it, not even in possible insights that can be garnered out of it, but in the effects the correct analysis can have for example in agriculture by reducing number of chemical treatments and thus lowering soil and air pollution and increasing general health of the residents. We see that meteorological big data has already merged with a lot of industries: agriculture, transportation, power grid and tourism, etc. Agriculture links closely to meteorology, which provides precision farming, meteorological disaster monitoring and decision making support.

The evolution of big data has produced new challenges that needed new solutions. As never before in history, servers need to process, sort and store vast amounts of data almost in real-time. This challenge has led to the emergence of new platforms, such as Apache Hadoop, which can handle large datasets with ease. The Apache Hadoop is an open source software framework for efficient managing and processing of big data in a distributed computing environment. This library consists of four main modules: Hadoop Distributed File System (HDFS), Yet Another Resource Negotiator (YARN), MapReduce and Hadoop Common. HDFS is used for storage of the data, which is similar to that of a local file system on a typical computer, but is distributed. HDFS provides better data throughput when compared to traditional file systems. Furthermore, HDFS provides excellent scalability: from a single machine to thousands with ease and on commodity hardware. YARN is used for scheduling tasks, whole managing, and monitoring cluster nodes and other resources.

The Hadoop MapReduce module helps programs to perform parallel data computation. The Map task of MapReduce converts the input data into key-value pairs while reduce tasks consume the input, aggregate it, and produce the result. Hadoop Common uses standard Java libraries across every module. Although Apache Hadoop is designed to work with any type of data, meteorological data processing using this platform can be from the utmost importance in agriculture. Today there is an urgent need to produce more food for the growing population – with less land to grow it on, while taking care of chemical pollution. One way of addressing this challenge is big meteorological data processing. IoT devices and meteostations help in the first phase of this process — data collection. Sensors plugged in tractors and trucks as well as in fields, soil, and plants aid in the collection of real-time data directly from the ground. Second, analysts integrate the large amounts of data collected with other information available in the archive to determine patterns. Finally, these patterns and insights assist to pinpoint existing issues, like operational inefficiencies and problems with soil quality, and formulate predictive algorithms that can alert even before a problem occurs.

III. METEOROLOGICAL AND SPATIO-TEMPORAL COMPONENTS OF THE METEOROLOGICAL STATION

The process of modeling the meteorological station included selection of sensor components for measuring the air temperature, relative humidity, precipitation, wind speed, soil moisture and humidity of the leaf of the plant. In addition to the mentioned sensors, the model envisages the existence of a computer, a module data exchange between the meteorological and base station, as well as the power supply system. Each component of the meteorological station model was selected by comparing technical, financial and compatibility characteristics of a larger number of components.

The coordination of the operation of all sensor components is done using the Raspberry Pi 3 Model B computer. Raspberry Pi is a small-sized computer supporting GNU/Linux platform and Windows 10 platform [4]. It is based on Broadcom BCM2837B0, ARM Cortex-A53 64-bit processor with four cores, each core having its own L1 memory. Connecting the sensors to this computer is done using forty General Purpose Input/Output (GPIO) pins divided into three banks, each of which has its own VDD input pin. GPIO pins can be configured as general-purpose input pins or output pins or as one of six alternate special purposes. Each sensor is powered through the power pins of each of the banks. Furthermore, this computer is equipped with USB ports that have been used to connect additional components.

A. *Temperature sensor*

Taking into account the fact that air temperature oscillates during the day, and that it can affect certain agricultural processes, it is from high importance to select the appropriate temperature sensor.

TABLE I. COMPARISON OF TEMPERATURE SENSORS

Sensor tag	**Comparison parameters**		
	Measuring range [ºC]	***Accuracy [ºC]***	***Power supply [V]***
DS18B20	-55 to +125	± 0,5	3,0 – 5,5
DS18B20-H	-55 to +125	± 0,5	3,0 – 5,5
DS1818-10	-40 to +85	± 8,5	3,3
DS1822	-55 to +125	± 2,0	3,3 – 5,5
DS18B20Z	-55 to +125	± 0,5	3,0 – 5,5

Temperature sensor analysis based on the characteristics provided by the manufacturer is shown in Table 1. The DS18B20 temperature sensor was selected for outside temperature measurements. This is the temperature sensor that comes with 91 cm long and 4 mm wide cable, allowing the sensor to be mounted at the most suitable position. Due to its connection possibilities and water resistance, it is perfect for use in outdoor conditions. The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. In addition, the DS18B20 can derive power directly from the data line. Each DS18B20 has a unique 64-bit serial code, which allows multiple DS18B20s to function on the same 1-Wire bus. Applications that can benefit from this feature include HVAC environmental controls, temperature monitoring systems inside buildings, equipment, or machinery, and process monitoring and control systems.

B. Temperature and relative humidity sensor

Relative air humidity sensors are most often found on the market in combination with temperature sensors. For this reason, the performance analysis of the most common temperature and relative air humidity was performed. The analysis included the range of measurements, the accuracy of both the part of the sensor for measuring the relative humidity, and the temperature part of the sensor. The data obtained by analysis are presented in Table 2. Another analysis can be performed taking into account the influence of external conditions on the operation of the sensor. Sensors HIH6030 and SHT1x series are marked as resistant to weather conditions. Detailed comparison and research found that the dust and condensation can interfere with proper operation of the HIH6030 sensor. Furthermore, SHTx series sensors have higher protection and ability to connect via cable. According to the technical characteristics, the SHT15 sensor is characterized by the most precise measurements. With the measurement range, power supply and external protection, the price difference between the SHT15 and HIH6030 sensors is canceled.

TABLE II. COMPARISON OF SENSORS FOR TEMPERATURE AND RELATIVE HUMIDUTY MEASUREMENT

Sensor tag	**Comparison parameters**		
	Measuring range	***Accuracy***	***Power supply [V]***
SHT15	0-100 %	±2.0 %	2,4 – 5,0
	-40 do +120 ºC	±0,3 ºC	
HIH6030	0-100 %	±4,5 %	2,3 – 5,5
	-40 do +100 ºC	± 0,5 ºC	
DHT22	0-100 %	± 2-5 %	3,0 – 5,0
	-40 do +80 ºC	± 0,5 ºC	
SHT10	0-100 %	±4,5 %	2,4 – 5,0
	-40 do +120 ºC	± 0,5 ºC	
SHT11	0-100 %	±3.0 %	2,4 – 5,0
	-40 do +120 ºC	±0,4 ºC	
AM2315	0-100 %	± 2,0 %	3,5 – 5,5
	-20 do +80 ºC	± 0.1 ºC	
DHT11	20-80 %	± 5,0 %	3,0 – 5,0
	0 do +50 ºC	± 2,0 ºC	

C. Percipitation sensor

This device is made as a funnel-laden vessel in which the rainwater is collected and channeled to the collection vessel. When a sufficient amount of water is accumulated, the container is overturned and discharged. At the same time, the opposite side container is positioned in the filling position. The amount of water needed to make the vessel roll over and its discharge is 0.2794mm of rain, so the device can record small amounts of precipitation.

With each discharge of the vessel, the closing of the electric circuit is carried out by means of a switch, triggering a digital counter or sending interrupt to the microcontroller. The total amount of precipitation for a given period is calculated by multiplying the counter value and the amount of water needed to initiate the discharge.

Although it usually comes equipped with an RJ11 connector, if this option is not available, it can be connected via GPIO pins by removing the plug and connecting the wire. The main advantage is the operation without an external power supply.

D. Wind speed sensor

The wind speed sensor is or an anemometer consists of several hemispheres that rotate on a common axis under the influence of wind. The simplest mechanism is based on the mechanical action of the magnet on the switch, as was the case with the rainfall sensor. In Table 3, a comparison of different anemometers available on the market is given.

The basic difference between the selected anemometers is the accuracy, output signal, and the sensitivity of the anemometer itself or the minimum wind strength required to start the rotation. Adafruit1733 anemometer was selected for the realization of the meteorological station for its resistance to weather conditions, corrosion and the influence of moisture.

This sensor has a defined limit regarding the outdoor temperature boundaries at which can operate – from -40ºC to + 80ºC. Furthermore, the selected anemometer comes with a power cable and a transmitted reading of 3m length, which allows it’s positioning to the top of the carrier.

Based on all observed parameters, it was selected Adafruit 1733 wind speed sensor. This sensor has the largest measuring range. also the power supply is in line with the output power of the microcontroller.

TABLE III. COMPARISON OF SENSORS FOR WIND SPEED MEASUREMENT

Sensor tag	**Comparison parameters**			
	Start speed [m/s]	***Measuring range [m/s]***	***Accuracy [m/s]***	***Output signal [V]***
Adafruit 1733	0,2	0,5 - 70	± 1	0,4 - 2
BAN 1093558	0,2 - 0,4	0,2 - 32,4	± 1	0,4 - 2
JL-FS2	0,4 - 0,8	0,0 - 30	± 1	0 - 5
Met One 010C	0,22	0,0 - 50	± 0,07	11
Met One 013	0,45	0,0 - 67	± 0,11	11

E. Soil moisture sensor

Soil moisture sensor perform a constant measurement of the amount of water at the surface level of the soil. The soil moisture sensor is placed below the ground level at a predetermined depth. The principle of operation of available soil moisture sensors is based on two probes. Through the probes, electricity is transmitted to the ground, after which the moisture level is calculated based on the measured resistance. Higher soil moisture allows better conductivity, and therefore less resistance.

Octopus sensor for measuring soil moisture was selected for the realization of the meteorological station model. This sensor is powered by a constant power supply of 3.3V to 5V, which corresponds to the needs of the meteorological station implementation, as the power can be fed directly from the Raspberry Pi device or from the external power supply. The output signal transmitting the measured value is within the limits of 0 – 4.2V, which also corresponds to the needs of model realization.

F. Leaf wetness sensor

Leaf wetness sensors measure the dielectric constant of the upper surface of the sensor, and can detect the small amount of water or ice on its surface. Table 4 gives an overview of sensors available on the market and covered by the analysis.

From the group of analyzed sensors, a Decagon sensor was selected. It measures the dielectric constant in the zone approximately 1cm above the surface of the sensor. It is known that the dielectric constant of water is 80, ice 5, which is considerably larger than the dielectric constant of air, which is 1.

The sensor emits a signal in mV proportional to the dielectric value in the measurement zone, and therefore proportional to the amount of water or ice on the surface of the sensor. The thickness of the fiberglass from which this sensor is made is 0.65mm, which is approximately the thickness of the plant's leaves. For this reason, condensation of moisture on the sensor as well as its evaporation is performed at the same speed as on the natural leaves. Sensor can be connected in two ways: using a Decagon data logger or using another similar device. As the proposed model of the meteorological station does not use the Decagon data logger, the connection is done via GPIO pins.

TABLE IV. COMPARISON OF SENSORS FOR LEAF WETNESS MEASUREMENT

Sensor tag	**Comparison parameters**			
	Power supply [V]	***Output voltage [mV]***	***Working temperature [ºC]***	***Cable length [m]***
Decagon	2,5 - 5	320 - 1000	-20 do +60	5
PHYTOS 31	2,5 - 5	320 – 1250	-40 do +50	5
Vantage Pro	3,0	2500 – 3000	-20 do +60	5
ADCON Wet	2,2 – 12,0	0 - 2500	-20 do +60	3
260-RK300-04	12,0 – 24,0	0 - 5000	-40 do +70	3

G. GPS module

The spatio-temporal attributes of each data packet sent from the metrology to the base station as is significant if there exist meteorological station system connected to a single base station. Regardless of whether there is one or more meteorological stations, the time component is significant for recording of the time in which the meteorological parameter values were read. A spatial component on the other hand is not needed if there is only one meteorological station and if it is always in the same location. For the purposes of determining the space-time coordinates, a GPS module has been introduced into the meteorological station model.

Adafruit PA6H1F1702 GPS module was selected for the realization of the meteorological station. It is based on MTK3339 chipset – a high quality GPS module, which can track up to 22 satellites through 66 channels. The main characteristics are a highly-sensitive receiver of -165dBm in tracking, built-in antenna, low energy consumption of up to 20mA when positioning, and sleep mode with even lower energy consumption.

IV. PACKET DATA TRANSFER COMPONENTS

Transmission of data packets containing recorded meteorological and spatio-temporal parameters requires communication between the meteorological and the base station. Taking into account the distance between the meteorological and the base station, one of the possible communication solutions is based on the use of wireless telecommunication systems for data transmission using radio frequency or data transmission via GSM/GPRS network.

Packet data transmission can be realized by adding a radiofrequency transceiver to the meteorological and base station. The network topology of devices is conditioned by the configuration of the terrain and the maximum visibility line between the base and meteorological stations [5]. When choosing a radio frequency transceiver it is important to select one that can be connected to and powered by a Raspberry Pi computer. Different families of radio frequency modules suitable for transmitting data from the meteorological station are available from Digi International. Each of the families is characterized by the different functionalities. After the elimination of certain RF module categories, based on the technical characteristics of the remaining families and categories, the Digi XBee S2C 802.15.4 category is chosen.

Transferring data from one mobile device to another can be done using the Global System for Mobile Communication or the GPRS (General Packet Radio Service) network. GSM is a European standard for digital mobile systems based on the use of three different frequency bands. The advantages of this technology are international traffic, high quality voice transmission, increased security and support for the implementation of various other services [6]. Considering the limited power options, the connection methods and the open weather conditions of the meteorological station, one of the options is the SIM900-TTL UART GSM/GPRS model from Rhydo Technologies (P) Ltd. The aforementioned GPS/GPRS TTL UART modem is based on the Quad-band GSM/GPRS machine in the SIM900A tag. This engine works at 850MHz, 900MHz, 1800MHz and 1900MHz. It is very compact in terms of size and usage within the GSM modem. This modem is designed to operate within a 3.3V/5V TTL circuit, allowing it to be directly connected to both 3.3V and 5V microcontrollers [7]. The bandwidth can be adjusted in the range of 9600kb/s to 115200kb/s. The bandwidth is set using the AT command, with initial value of 9600kbps. The connection of the modem with the microcontroller is based on two communication conductors (Tx, Rx) and one conductor for power supply [8]. This GSM/GPRS TTL modem has an internal TCP/IP stack that allows establishing Internet connection via GPRS. It is suitable both for sending SMS messages and for sending data packets via TCP/IP, as is the case with a meteorological station.

Parameters for comparing the selected radio frequency and GSM/GPRS modules are: module connection, power consumption, maximum possible distance between the meteorological and the base station, data transfer rate. The complete comparison of the ZigBee XBee S2C 802.15.4 radio frequency module with the SIM900 GSM/GPRS module has shown that the SIM900 GSM/GPRS module is a better solution for communication in the meteorological station system. A wireless telecommunication system with this module assures greater mobility of the meteorological station, distance-independency communication between meteorological and base station, and higher data transfer rate. The higher energy consumption of this module compared to the selected RF module is a negligible fact in relation to all of the above mentioned advantages.

V. Power Supply Of The Meteorological station

The described meteorological station is a set of electronic devices that require a constant power supply throughout the entire period of use for normal operation. Because of that, the agricultural meteorological station model envisages an alternative power supply using a photovoltaic panel and a rechargeable battery, to ensure its active use throughout the year. Rechargeable battery is introduced for days with the reduced number of sunny hours.

As one of the main components of the meteorological station, The Raspberry Pi computer requires a constant voltage of 5V. Furthermore, all selected sensors and devices work at the same or lesser voltage, provided using the input/output pins or the USB port of the Raspberry Pi computer. Two modes of operation can be defined: active and passive. In order to determine the required power of the photovoltaic panel as well as the capacity of the batteries, the maximum consumption of the entire system was calculated. In order to calculate the maximum energy consumption, it is assumed that the readings of the parameters are carried out every 15 minutes.

The maximum active time during the reading is one minute, which is theoretically more than the time stipulated in the technical documentation. The difference in duration between the active mode defined by the technical documentation for each of the sensors and the defined time of one minute has been included in the calculation to cover reading errors causing the re-reading process to start. Based on the data, one-hour power consumption of the meteorological station in the passive operation can be 25.2mAh, while in the active mode the consumption is 2546.273mAh. The power supply of all consumers is with DC voltage $U_0 = 5\text{V}$, whereby the data on the daily consumption of electricity is:

$$P_0 = U_0 \cdot I_0 = 5V \cdot 61{,}11056Ah = 305{,}5528\text{Wh} \qquad (1)$$

Based on the daily electricity consumption, the power of a photovoltaic panel which represents the power of the electricity generated by the panel at a solar radiation intensity of 1000W/m^2 can be calculated. Firstly, the average number of hours of peak sunlight is calculated for most favorable month, according to the formula:

$$N_{PS} = \frac{H(W_h/m^2)}{1000(W/m^2)} \qquad (2)$$

Where $H(W_h/m^2)$ is the average intensity of the solar radiation in the most unfavorable month of the year. The month with the lowest intensity of sun radiation and the optimal elevation angle of the panel for that month are determined by the location on which the panel and devices will be set up. For the purposes of this research, the chosen location for the meteorological station is 43.163791N, 21.362126E. The calculation of the month with the lowest intensity of solar radiation was done using a service created by the European Commission's Joint Research Center. Based on the report generated by this service, the required elevation angle of the photovoltaic panel is 63º in relation to the horizontal plane. The value of the average daily amount of global radiation after calculation is 2,06kWh/m^2. Based on this data, the average intensity of solar radiation in December is $H = 2060Wh/m^2$. By replacing the obtained value for the intensity of solar radiation within the equation for the number of hours of peak sunlight in the least favorable month, the following value is obtained:

$$N_{PS} = \frac{H(Wh/m^2)}{1000(W/m^2)} = \frac{2060Wh/m^2}{1000(W/m^2)} = 2{,}06h \qquad (3)$$

The power of the photovoltaic panel $P(W_P)$ whose daily consumption is $P_0 = 305{,}5528\text{Wh}$, is obtained based on:

$$P = \frac{P_0}{N_{PS} \cdot E_{REG} \cdot E_{BAT}} \qquad (4)$$

Where E_{REG} represents the efficiency of the charging regulator, while E_{BAT} the efficiency of the batteries. Based on the values of all parameters, the power of the photovoltaic panel is obtained:

$$P = \frac{P_0}{N_{PS} \cdot E_{REG} \cdot E_{BAT}} = \frac{305{,}5528Wh}{2{,}06h \cdot 0{,}9 \cdot 0{,}9} = 183{,}119W_P \qquad (5)$$

Based on the obtained value for the power of the photovoltaic panel, and available models, it is necessary to install two 100W_P photovoltaic power panels.

Along with calculating the strength of the photovoltaic panel, the battery capacity was calculated. When calculating the capacity of the battery, two consecutive days of total darkness are considered (N_{SOL}=2). Furthermore, the voltage of the battery from V_{BAT}=12V and battery efficiency factor from E_{BAT}=80% were adopted.

In addition to the battery efficiency factor, it is also necessary to define the depth of battery discharge, with the general recommendations of the battery manufacturer of D_{BAT}=80%.

The last parameter needed for required battery capacity calculation is the degradation of the battery capacity due to the temperature drop (Ct_{BAT}). As the metrological station was designed for operation in the winter months, it was assumed that the battery operated at a temperature of 0ºC. This practically means that its available capacity with additional isolation due to a fall in temperature is reduced to the value Ct_{BAT}=80%.

The required battery capacity is obtained by replacing the values of all the mentioned parameters within the following equation:

$$Q_{BAT}=\frac{P_0\cdot N_{SOL}}{V_{BAT}\cdot E_{BAT}\cdot D_{BAT}\cdot Ct_{BAT}}=\frac{305.5528Wh\cdot 2}{12V\cdot 0{,}8\cdot 0{,}8\cdot 0{,}8}=\frac{611{,}1056Wh}{6{,}144V}=99{,}46Ah$$

The agricultural meteorological station should as a power supply use a 12V battery of 100Ah. Choosing a 12V, 100Ah battery requires the introduction of a voltage regulator to reduce the voltage from 12V to the operating voltage of a Raspberry Pi - 5V. In addition to the charging regulator, the voltage regulator is introduced to protect other hardware devices from possible damage due to voltage changes.

VI. CONCLUSION

Monitoring of meteorological and spatial-temporal parameters is of great importance for agricultural production. The proposed conceptual solution of meteorological station can be used for measurement of the most significant parameters. The accuracy and compatibility of the selected sensors lead to appropriate performance with the realization cost considerably lower than the price of available commercial solutions. Meteorological station mobility, remote access, selected group of sensors and the price of the realization contribute to the practical realization and use of this station by small agricultural producers and organizations, and therefore can be used to improve the process of agricultural production.

The continuation of this research will be reflected in the practical realization of the proposed model. The practical realization will enable the testing of individual components, testing of entire model, as well as the communication of several meteorological stations united in a common system. The practical realization will provide real data on the correctness of this model. Also, the practical realization will include checking the accuracy of the obtained measured values by comparison with the obtained values from commercial meteorological stations.

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