National research & education network of meteorological monitoring in V. I. Vernadsky Crimean Federal University

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Abstract. The article describes the experience in organizing work of the meteorological monitoring network across the Republic of Crimea based on the best available technologies. V.I. Vernadsky Crimean Federal University applied approaches of the meteorological monitoring network for scientific and educational purposes. According to the studies, technical requirements, methodological approaches in organizing meteorological measurements and educational and practical base for students training and retraining were formed. The monitoring system allows collecting detailed meteorological data in the ground layer and studying the local formation features of hydrometeorological parameters across various natural climatic zones and landscapes in Crimea. The article also provides methodological requirements and results on creating system for collecting, storing and processing information on a personal server by organizing a thematic geoportal and visualizing data using web gis. According to the research results, we received appropriate patents, created an educational platform and a competence centre for training and re-training staff in subject-matter and related specialties in the Crimea in order to form knowledge, skills and abilities in the field of regional meteorological monitoring.

1. Introduction
Over the past 60 years, V. I. Vernadsky Crimean Federal University has been conducting systematic scientific research in the field of climate change in the South of Russia, including the Southern Federal District and, above all, the Republic of Crimea. The completed research topics received positive feedback about scientific content and practical achievements in the Academy of Sciences of the USSR, the National Academy of Sciences of Ukraine, the Russian Academy of Sciences, the FANO, and the Ministry of Education and Science.

The university has developed a highly qualified staff capacity and climate change scientific school. A wide range of publications (including international databases Scopus, WoS, ERIH), patents, monographs, specialized textbooks and scientific and methodological aids confirms it. Relevance, accuracy and representativeness of meteorological observations system is in a research process [1-5].

A special focus is on the spatial representativeness of the Crimean meteorological observations network data. The Crimean spatial zones were identified according to the landscape conditions within which the data of monitoring observations corresponded to the real picture of meteorological parameters distribution [6-9].

Studies are also being conducted on the accuracy and representativeness of information on the meteorological parameters background values and atmospheric air pollution parameters [10, 11].
In modern conditions, the use of measuring automatic methods and environmental monitoring recording meteorological parameters is an advanced trend [12-18].

It requires the methodology development for training specialists with the set of appropriate competencies and creating a specialized educational platform on the territory of the Republic of Crimea.

During 2019-2020 V.I. Vernadsky Crimean Federal University «Cyberagronomy» Research Centre based on the pure and applied research of V.I. Vernadsky Crimean Federal University «Agrometeorological monitoring system in Republic of Crimea» was created.

2. Problem statement
The purpose of the study is to organize a system of macroregional agrometeorological monitoring and forecasting for the creation of V.I. Vernadsky Crimean Federal University specialized competence center.

The novelty of the research: the monitoring system allows collecting detailed meteorological data in the surface layer of the atmosphere. It provides an opportunity to study the local hydrometeorological features parameters formation on the Crimean territory landscapes, to provide the detailed data for the region climate study, agricultural production and to give the possibility of using these data and methods in the educational process at V.I. Vernadsky Crimean Federal University.

3. Methodology and methods
The autonomous meteorological monitoring system is based on the network of Sokol-M meteorological station.

Network is spatially differentiated in 12 Crimean regions (Prisivashye central Crimean part, Saki District, Soviet District, Simferopol District, Simferopol, Peschanoe, Foros, Alushta, Feodosiya, Kerch, Okunevka) due to 12 autonomous agrometeorological stations. It takes measurements, fixation and forecast about 15 agroclimatic parameters, recording, storage and data processing in the relevant server with 3-minute interval fixation within 15 km.

Based on the automatous meteorology module station results regularly updated agrometeorological database is formed.

A meteorological station fixes agrometeorological indicators 1 time per 20 minutes. Then the data are recorded on the maker’s server and V. I. Vernadsky Crimean Federal University server with subsequent parameters processing and analyses. The indicators, being fixed automatically, are as follows: air temperature, degrees Celsius; UV level (W/m²), precipitation (mm); atmospheric pressure (hPa); wind direction (degrees), relative air humidity (%); wind speed (m/s).

The database is used in the scientific research and in V.I. Vernadsky Crimean Federal University structural divisions educational process. The computer types are IBM PC; the compatibility PC is Windows XP/Vista/7/8/10, Linux, MAC OS.

4. The main part
V.I. Vernadsky Crimean Federal University’s Meteorological measurement’s system so far involves 12 automatic agrometeorological stations. The meteorological stations are located in the regions of university’s agricultural enterprises locations and in regions poorly covered by the Roshydromet monitoring system.

The Roshydromet monitoring system includes 16 agrometeorological stations and posts in the Republic of Crimea. V.I. Vernadsky Crimean Federal University’s agrometeorological stations locations in spatial patterns will complement existing observing networks.

For natural landscapes and agricultural lands in Steppe and Foothill parts of the Crimea such a study have not been done yet.

The project is integrated and includes the following tasks:

Educational tasks:
- Creating a competence center in the field of meteorological monitoring on the basis of V.I. Vernadsky Crimean Federal University
- Providing the staff, graduates and undergraduate students of V.I. Vernadsky Crimean Federal University with the current meteorological information, that contributes to the related research. For today these data are widely used by Taurida Academy and Agrotechnology Academy staff and graduate students for studies of the Crimean regions and the field research;
- Creating a platform for specialists’ training to build the respective fields of competence. For undergraduate student’s significant work has been undertaken to devise methodological support and skill system in the regional meteorological monitoring field.

Research tasks:
- Organization of agricultural production micro-climatic conditions for the scientific research in the case agricultural holdings models;
- Organization of agricultural production micro-climatic conditions for the scientific and ecological research in the natural climatic Crimean zones;

Practical tasks:
- Creating V.I. Vernadsky Crimean Federal University micro-climatic conditions and farming databases;
- Meteorological data integration into Geographic Information System as the main conduct and administration of the agricultural proceedings that examine modalities and the factors which are developed and tested;
- Analytical support of managerial decision-making and effective evaluation of agro-technology transactions taking into account meteorology forecast and their dynamics.

Production:
- Creation of a comprehensive system for meteorological data accounting, monitoring and recording weather conditions based on the best available technologies of V. I. Vernadsky Crimean Federal University agriculture activities.

Functions:
- To provide more relevant information on the status of the meteorological components of environmental and agricultural landscapes;
- Maintenance of geographical information capacity for the agricultural output management decisions;
- Meteorological monitoring of parameters using the geographic information technologies and remote sensing technologies.
- Meteorological remote sensing data verification from the climatic satellites and stations V.I. Vernadsky Crimean Federal University.

The target group of the Center’s products consumers: agricultural businesses, V.I. Vernadsky Crimean Federal University structural units (staff, graduates and undergraduate students), municipalities, specialized government bodies.

During 2019-2020 the following tasks were completed:
- Scientific basis for the automatic meteorology stations location was selected;
- Agrometeorological stations were set for the experimental bench testing and were connected to remote servers; a registration in data acquisition and data storage system was done;
- Agrometeorological stations equipment’s and installation system preparation;
- Field visits and agrometeorological stations installation;
- Operational agrometeorological stations maintenance was carried out; SIM-card established; pads for fixing stations were constructed;
- Work on the use of agrometeorological stations database was organized based on our own and vendors' servers; agrometeorological stations settings and accounts registration was done.
- Ensuring the access for V.I. Vernadsky Crimean Federal University’s staff to the results of the work, meteorological data and predictive analysis (at agrometeorological stations sites and shared access to databases) for use in farming, scientific research and field research;
Agrometeorological monitoring copying, archiving and data storage for the period January-December 2020 as database at 3-10-20 minutes intervals from 12 weather stations on 8 parameters;

V.I. Vernadsky Crimean Federal University microregional agro-meteorological monitoring system was prepared for patenting. It is planned to obtain 12 patents in the period of October-December 2020 [19, 20];

A personal server for reception, storage and analysis agro-meteorological monitoring data with the ultimate aim of self-sustainment of V.I. Vernadsky Crimean Federal University microregional agro-meteorological monitoring system was established.

The result of the monitoring system is a regularly updated agrometeorological database.

For the application of the system in the educational process, based on the research results, technical and methodological requirements were developed.

Figure 1. V.I. Vernadsky Crimean Federal University GIS portal meteorological parameters monitoring.

Figure 2. Meteorological station network software interface.

V.I. Vernadsky Crimean Federal University agro-meteorological monitoring system has intuitive user interface and included:

- General appearance of the web pages displays monitoring data. Tab «Monitoring» is intended for displaying the map with agrometeorological stations names and locations.

- A full map coverage with all the available agrometeorological stations was done.
- «Monitoring» tab let look at the latest reported data by clicking on the agrometeorological stations title.

- On the left pane, under the «Desktop» tab you have options of choosing agrometeorological stations and obtain data in a user-friendly format for the future analysis. For example, «Graph readings» can be customized for a specific date and time. It is possible to view graphs over a long period. You may add different agrometeorological stations graphs with separate blocks and save them in graphical formats.

- It provides tools for agrometeorological stations graphs visualization over a long period.

- Section «Set of readings» in the «Desktop» tab allows getting meteostations sensors values for defined period in tabular form and export it in popular formats (.csv; .xls et al.) which enables data analysis in other programmes.

- Section «Wind rose» in the «Desktop» tab allows visualizing the values of wind velocities and direction for a defined time period with an export option in graphical formats.

- Section «Notification» displays server message list about the events, configured individually for each weather station. All messages were copied and sent via e-mail.

- Section «Device» allows seeing all the available weather stations list and its database. Also, in this section you can change settings for each weather station individually.

Figure 3. Agrometeorological stations and testbed exterior view.

The data about agrometeorological stations are accessible and represented on the online-map. First, using «QGIS» software agrometeorological stations Sokol-M real-time location project was done as it was mentioned on the free OSM map and pixel layer. The name attributes with agrometeorological parameters were established for pixel layers. For the pixel layers the named attributes with regularly updated agrometeorological parameters were established. Using the "qgis2web" module, the resulting project and JavaScript with the data displayed on the map were exported to an HTML page. We get a static map with the ability to change the data on the map by changing the parameters in the scripts.

The next step was to create a server application in the Python 3 programming language. Operating modalities for application were: to send a request on meteorological station vendors' servers to get a response with a list of parameters received over the last two days. Once received, meteorological parameters list application recording the data acquired in JavaScript. As a result, the following map parameters are updated: date and time of receiving the latest meteorological stations data, air temperature, wind speed, atmospheric pressure, UV index, total precipitation for the last 2 days, autonomous meteorological stations battery voltage. Requests are sent to the vendors' servers and updates map once per minute, thus ensuring highly up-to-date data. The function of direct connection of meteorological station to the university server was also added, this map extraneous factors were independent.
During 2019-2020, the university formed a material, technical, program and methodological base in order to create a Competence Center in the field of agroecosystems and their monitoring Scientific research. One of the components of the Center is a monitoring meteorological parameters system in order to provide up-to-date meteorological information for V.I. Vernadsky Crimean Federal University the Educational, Scientific and Technological Complex (the complex includes more than 4,000 hectares of agricultural land). For today, systematic work is underway to achieve the grounds for licensing in the field of the Regulation subject.

Such a system for monitoring meteorological parameters is unique for universities in the Russian Federation and was created on such a scale for the first time. The monitoring system allows you to detail and supplement Roshydromet observations data.

This monitoring system has an important pragmatic meaning for the university in terms of agricultural activities, specialized structural divisions and scientific research.

5. Conclusions

1. Research has led to formation of scientific - methodical and educational bases in V.I. Vernadsky Crimean Federal University which will provide skills training and retraining using the most perspective and in-demand meteorological technologies.

2. Monitoring activity included covering meteorology during 2020. Agro-meteorological monitoring systems SSRC «Cyberagronomy» of V.I. Vernadsky Crimean Federal University also included databases maintenance and systematization in 12 regions. (Prisivashye central Crimean part, Saki District, Soviet District, Simferopol District, Simferopol, Peschanoe, Foros, Alushta, Feodosiya, Kerch, Okunevka)

3. According to the results of the study scientific and technical tasks content on the application of the best technologies for remote meteorological monitoring hydrometeorological parameters for the territory of various natural and climatic zones and Crimea’s landscapes was formed.

4. The results of the study were used to develop the criteria and requirements for educational trajectory creating in the field of climate monitoring based on the using the best available technologies for Crimean students, employees of local self-government bodies, agricultural enterprises and industry specialists.

5. Organization of the server to receive, store and analyse meteorological monitoring database’s work was carried out in order to ensure self-sustainment of the microregional agrometeorological system in V.I. Vernadsky Crimean Federal University.

6. Based on the meteorological monitoring system of V.I. Vernadsky Crimean Federal University 15 patents in the field of monitoring meteorological parameters, GIS platforms software modules, Web-GIS and meteorological parameters databases were prepared.

7. Students of V.I. Vernadsky Crimean Federal University for determination of competences efficiency and level of training to use promising monitoring technologies subject matter were involved.

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