e-ISBN 978-9975-155-54-0, DOI 10.5281/zenodo.5732859

SATELLITE MONITORING OF AGRICULTURAL LAND

[1]Atanasov Asparuh, PhD Student, Assistant Professor
e-mail: asparuh.atanasov@tu-varna.bg
[2]Demirev Vladimir, Senior Assistant Professor, PhD
e-mail: vl.demirev@tu-varna.bg
[3]Mihova Galina, Associate Professor, PhD
e-mail: gmihova1971@abv.bg

[1,2,] Tehnical University of Varna
1 Studentska Street, 9000 Varna, Bulgaria
Web page: tu-varna.bg

[3] Dobrudzha Agricultural Institute, General Toshevo, Bulgaria
Web page: www.dai-gt.org

Abstract: *The object of the present work are the satellite images of agricultural lands, in order to obtain additional information about the development of crops. Farmers cannot afford to process "raw" satellite images, but there are companies available around the world that supply up-to-date images. In addition to images in a wide frequency range, users are offered meteorological information about the terrain, recommendations for fertilizer application and crop treatment, time series and total values of temperatures, precipitation, vegetation indices and the like. The space segment in the collection of data on agricultural crops has become increasingly relevant in recent decades and is an integral part of a comprehensive approach to precision agriculture. The study aims to trace the opportunities and differences in different sources of information.*
Key words*: satellite images, vegetation indices, precision farming, NDVI.*

JEL CLASSIFICATION: O13

1. INTRODUCTION

The rapid development of digital technologies and communications does not overtake agriculture. More and more processes, equipment, data collection and processing are based on digitalization and automation. What's more, modern communications allow most of the information we need about the state of crops and equipment to be received remotely, no matter where we are at the moment. In order to achieve real efficiency of the monitoring systems, a complex approach is needed in their construction: processing of data on the crops and their cultivation for a period of several years; expected yields of the current crop; meteorological data and forecasts; tracking crop development and soil condition through field observations and tests, through autonomous meteorological stations, through low-flying unmanned aerial vehicles, through satellite images in a wide frequency range. Obtaining and processing large amounts of information has in most cases proved impossible for manufacturers and they often turn their backs on new technologies, which reduces their competitiveness. For this reason, this study will compare different sources of data on freely accessible agricultural land. And a comparison of the information will be made when using the different sources.

2. MATERIAL AND METHOD

The object of the study are agricultural areas in the region of Dobrogea, sown with winter common wheat. Special attention is paid to a field with an area of about 0.06 km^2, near the town of Dobrich, which can be observed continuously from a distance of 300 meters, (GPS coordinates- 43.549519, 27.837412). Observations also include periodic on-site visits, sampling, satellite observations (mostly NDVI), and surveys of producers.

e-ISBN 978-9975-155-54-0, DOI 10.5281/zenodo.5732859

The summary report for the region of Dobrogea shows a significant deviation of the main meteorological factors in the harvest 2019 - 2020. In general, they are extremely unfavorable for cereals, and when comparing them with the average long-term data, several main trends stand out:

1) extremely insufficient precipitation during the autumn-winter period and deepening drought until it reaches economic maturity;

2) high average daily and absolute maximum temperatures during the winter months;

3) return frosts during the restoration of the spring vegetation;

4) intensive amounts of precipitation in wax maturity.

The picture was multi-layered and the result of the accumulation of many types of stress, technological solutions and varietal composition. Initially, uneven germination and thinning crops are observed. At a later stage, the long and warm autumn, the fallen although insufficient rainfall favored mass fraternization of crops. However, the conditions did not allow the plants to go into complete dormancy. During all ten days of December, January and February the average daily temperatures are positive, and the absolute maximums by months reach 19.5ºC, 15.5ºC and 20ºC. Significant leaf mass was formed, but soil moisture was below the critical minimum. In March, the picture became more complicated when, after a period of warming with maximum temperatures above +20ºC, minimum temperatures up to -4.5 C were reported on several consecutive days. The degree of damage was directly related to the condition of the crop and the genetic characteristics of the variety. Particularly problematic were crops where the decision on the timing of spring feeding and the amount of imported products was incorrectly chosen. At the next stage, the deepening drought did not allow some of the brothers to develop. Some of them reached hatching, but subsequently dried up. In combination with the low atmospheric humidity, a high percentage of sterility was achieved. The rains in June were too late and rather worsened the condition of the crops, leading to mass development of saprophytes and deterioration of the physical properties of the grain.

Satellite observations have been made with specialized free-access products available on the Internet, based on images from satellite earth observation missions, (Sentinel 2, for example). Some of these products are for commercial purposes, but also offer free packages that provide a different set of data and recommendations: maps of vegetation indices; weather forecast; yield forecast; recommendations for pesticide treatment; recommendations for fertilization and its corrections; assessment of productivity areas; precipitation, etc. The data obtained in this way are oriented directly to the users and save the need to process the "raw" data received from the satellites. From the identified several dozen software products for processed satellite images are selected: One Soil, EOS Crop Monitoring, LandViewer, Agro API and Sentinel EO Browser. Images of the vegetation index NDVI for the period from January to June 2020 for the field with an area of 0.6 km^2 were downloaded and a comparison was made. A comparison of the NDVI index was made for other fields, terrains and forests and in other periods.

What are the mentioned sources of information:

The Earth Observing System (EOS) is a NASA program that includes a series of artificial satellite missions and scientific instruments in orbit around the Earth designed for long-term global observations of the earth's surface, biosphere, atmosphere and oceans. LandViewer is a simple, intuitive web interface that EOS provides as a direct marketing product to the public (Land Viewer: EOS, (2021)).

EOS Crop Monitoring is a platform for satellite monitoring of crops with a cloud service that uses space imaging to help growers monitor arable land by providing relevant up-to-date information about it (EOS Crop Monitoring, (2021)).

The EO browser is a web platform for remote monitoring data processing. As part of the Copernicus program, it aims to contribute to a global, continuous and easily accessible source of satellite data. The EO browser combines a complete archive of the Sentinel satellites, as well as the Landsat 5, 7 and 8, Envisat Meris, Proba-V and MODIS missions (Sentinel-hub EO-Browser3, (2021)).

One Soil is a software company based in Minsk, Belarus, providing users with data on pre-ordered fields (Free apps for precision farming, (2021)).

Agro API for the natural integration of satellite imagery in agricultural applications and machine learning (Agro API, (2021)).

3. RESULTS AND ANALYSIS

Data from various satellite missions is available on the Internet, from which images can be formed in a wide frequency range. The visualization is done through, (Geographical Information Systems) GIS programs, taking into account the large amount of data, the need for a serious computer configuration, paid access to some of the data, the need for a trained specialist. On the other hand, the above-mentioned platforms offer processed data, including free and easy to use, but rather intuitive. Scanning the earth's surface via satellites is at a distance of 600 - 700 kilometres and achieving high resolution is a serious challenge. In practice, a resolution of 10x10 meters is sufficient for terrains over several tens of square metres. Certain factors, the most important of which is the cloud cover, can degrade images and mislead users. The comparison of data from different sources, as well as data from periods within a few days is an opportunity to correct possible errors. It was also found that the dynamics of meteorological conditions during the vegetation development is very high. For example, rain, after drought, sharply increases the vegetation index, and areas with a small index, can subsequently improve their level.

What do processed data products offer? Careful analysis of the reflectivity of vegetation provides information on the stage of development, phytosanitary status and even the identification of individual plant species (Monitoring Vegetation From Space, (2021)).

- Data on the meteorological situation in a specific field at the moment and short-term forecast;
- Images of the terrain with the values of different vegetation indices;
- Recommendations for fertilization and treatment, based on the crop, precursors, set yields, meteorological data, etc.;
- Data on time series of different quantities: precipitation, total temperature, dynamics and comparison of vegetation indices;
- In addition to the values of the most popular vegetation indices, users can compose images at random, based on images in the multi-spectral range and encode the color values obtained, i.e. to compile their own vegetation indices;
- It is possible to make an approximate calculation for the expected yields based on the above data.

The approach of data providers is different. Some of the packages are research-oriented, others are more production-oriented. There is a limit on the data provided during (no more than 10 images per day) or demo and trial versions, a limit on the number of fields requested for observation or observed decares and the like. Probably the goal is to limit the commercial aspect of the information received.

What do the results of the study of processed satellite images show?

First of all, the comparison of the registered vegetation indices NDVI with the condition of the terrains checked on the spot shows very good data coverage: the green artificial grass of the stadium has a vegetation index of 0.2 - 0.3; the coniferous plantations in a mixed forest

e-ISBN 978-9975-155-54-0, DOI 10.5281/zenodo.5732859

massif have an index of 0.5 - 0.7, and the deciduous ones in the winter have an index of 0.2 - 0.3 and in May it reaches 0.7 - 0.8; the plowed area have an index of 0.2, and after the appearance of weeds - 0.4 - 0.6. (Free apps for precision farming (2021)).

Figures 1-3 show images of a field sown with wheat from different sources on the same day - 12.02.2020.

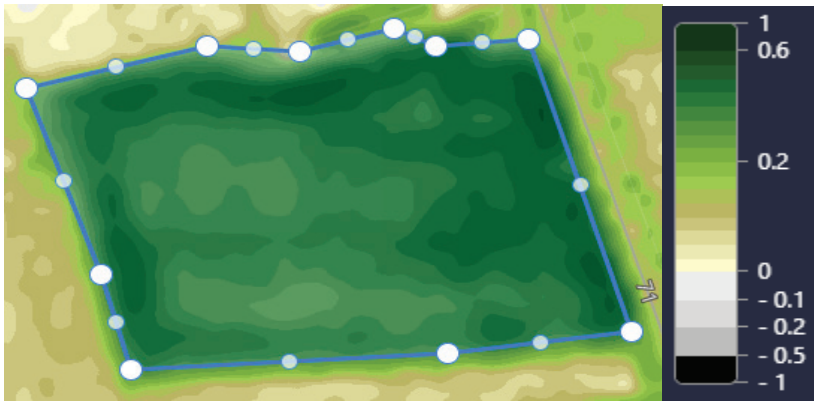


Fig. 1. LandViewer
Source: Land Viewer: EOS, (2021)

Fig. 2. One Soil
Source: Free apps for precision farming, (2021)

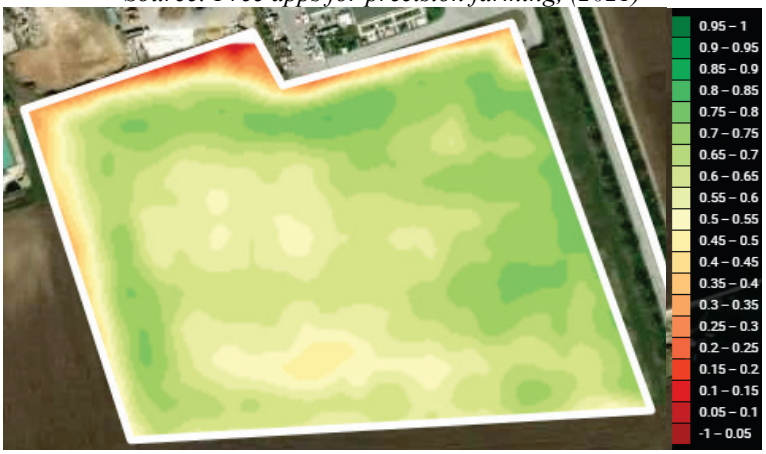


Fig. 3. EOS Crop Monitoring
Source: EOS Crop Monitoring, (2021)

The color coding of the NDVI index is different and this requires a scale comparison for each source. The resolution varies from source to source. It is usually 10 x 10 meters for free products, but One Soil offers a resolution of 5 x 5 meters. No significant differences between the

e-ISBN 978-9975-155-54-0, DOI 10.5281/zenodo.5732859

data from the sources are observed. The reported vegetation index NDVI is in the range of ..0.5 - 0.7. All figures with the same shape and coordinates are registered with lower vegetation index. With small deviations, the mentioned sections are registered in the neighbouring time periods.

In the data from LandViewer and OneSoil from 02.01.2021 significant deviations from the absolute value of the NDVI index for another field are registered: 0.8 against 0.5. As relative values, it can be argued that the two images are identical.

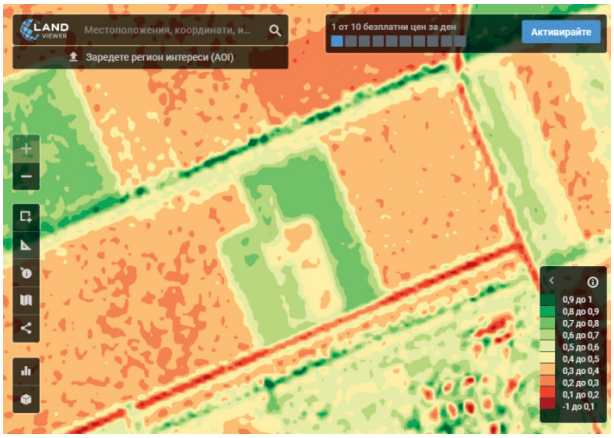


Fig. 4. LandViewer
Source: Land Viewer: EOS, (2021)

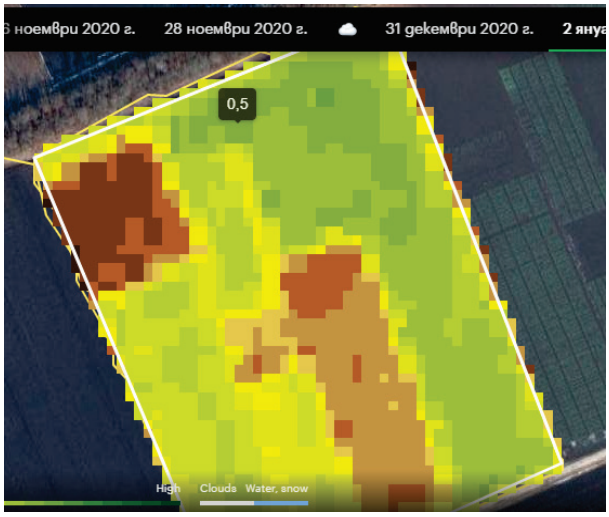
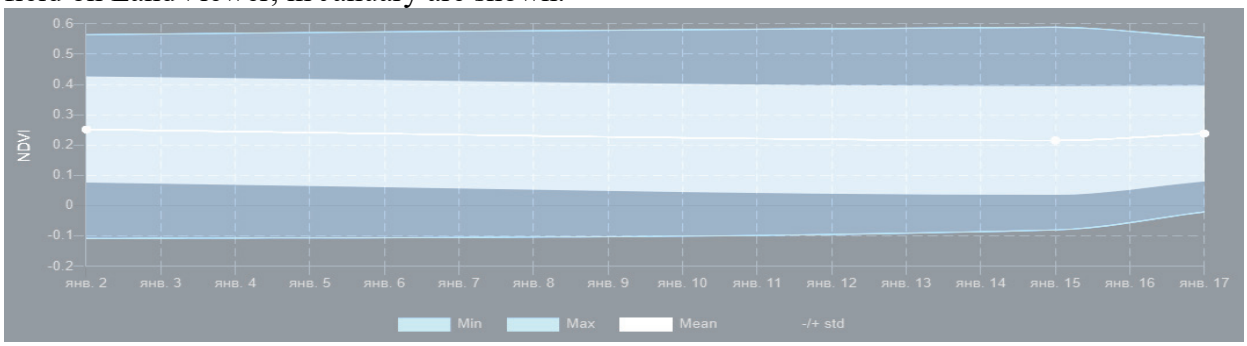


Fig. 5. OneSoil
Source: Free apps for precision farming, (2021)

In Figure 6. the maximum, minimum and average values of the NDVI index for the same field on LandViewer, in January are shown.



e-ISBN 978-9975-155-54-0, DOI 10.5281/zenodo.5732859

Fig. 6. Index values NDVI

The NDVI index is an indicator of the condition of plants and does not explain the reasons for their level and variation. At the beginning of the season, it is an indicator of the way the plants have overwintered:

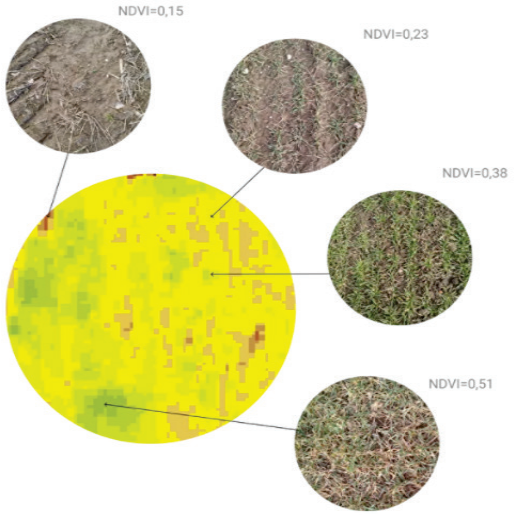


Fig. 7. Index NDVI
Source: Free apps for precision farming (2021)

• At values below 0.15 there is a possibility of a high percentage of frost;
• Values 0.15 - 0.20 are low, different degrees of damage are possible or the plants did not grow well enough when entering the winter months;
• The values 0.20 - 0.30 are relatively good and show a normal state of the crop for the development phase;
• The values 0.30 - 0.50 are inherent in strongly fraternal sowing or advanced phenological development;
• Values above 0.50 are not typical for the period before the restoration of vegetation and can be considered as anomalies, which requires examination to determine the causes.

As the photoperiod lengthens, wheat enters a spindle phase, when the stakes are set and a large amount of biomass accumulates. The period is critical and each type of stress affects the potential yield. The diet is extremely important for its realization. At this stage, the NDVI index is an indicator of how plants grow. If the values of the index are medium to high (0.5 - 0.85), most likely there are no stress factors in this part of the field. If the index is low, the probability of a technological gap in the diet, limiting factor of abiotic or biotic nature is high. The recommendation is a field inspection.

The values of the NDVI index can provide guidelines for corrections of imported fertilizer products.

If the vegetation index is high for the field area, it is recommended to reduce the fertilizer rate by 10 -- 30% depending on the soil and climatic conditions.

If the vegetation index is average, it is desirable to increase the fertilizer rate by 20 - 25% of the average.

If the vegetation index is low, it is mandatory to identify the reasons for this.

At the end of the season, the NDVI index helps to predict the onset of the appropriate harvest period. The low index is an indication that the plant is entering economic maturity. The approximate values are about 0.3 - 0.35.

e-ISBN 978-9975-155-54-0, DOI 10.5281/zenodo.5732859

The above recommendations are too general and cannot be a basis for decision making. Serious research shows that vegetation indices change with different varieties, climatic conditions, cultivation technologies, phenological phase, etc. The compiled models for the relationship between vegetation and the NDVI index correlate well with the real situation and can be a basis for forecasting yields.

4. CONCLUSIONS

- The review of the various sources for remote spectral observation - vegetation indices can help in the work of farmers. They can plan the appropriate treatments. Accordingly, they can reduce the time for direct monitoring of crops by monitoring only areas with a reduced index.
- Spectral reading methods give the necessary parameters most easily and quickly, even for large areas, as they are easy to use. The considered sources of information give easy access even for farmers without the need for them to be IT specialists to different information about the cultivated crops. And receiving from users information on meteorological information about the terrains, recommendations for fertilizer application and crop treatment, time series and total values of temperatures, precipitation, vegetation indices and the like.
- The graphical representation of the values of the sources gives similar information to all Figures. The same in shape and coordinates are registered areas with a lower vegetation index. Significant deviations from the absolute value of the index are registered in the various web resources, this is an indication that the color coding should not be absolute.

REFERENCES

Agro API (2021). https://agromonitoring.com/

Dobrich, Bulgaria. - Land Viewer: EOS (2021). https://eos.com/landviewer/?lat=43.56670&lng=27.83330&z=11

EOS Crop Monitoring - A New Farm Software For Agricultural ... (2021) https://eos.com/products/crop-monitoring/

Free apps for precision farming (2021). https://onesoil.ai/en/

Monitoring Vegetation From Space (2021). http://www.eumetrain.org/data/3/36/print.htm

Sentinel-hub EO-Browser3 (2021). https://apps.sentinel-hub.com/eo-browser/?zoom=10&lat=41.9&lng=12.5&themeId=DEFAULT-THEME&toTime=2021-08-03T11%3A08%3A42.718Z