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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

NEW MEASUREMENT AND VALIDATION METHODS IN THE ISSUES OF SPECTROPHOTOMETRIC ASSESSMENT OF AGRICULTURAL LANDSCAPE COMPONENTS

Speciality: 3337.01- Information- measuring and controlling systems

Field of science: Technical sciences

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GENERAL CHARACTERISTICS OF WORK

Relevance and development of the topic. Assessment of the condition of agrarian landscape components is one of the key issues as a complex problem. The flow of carbon dioxide *(CO_2)* generated on the surface of vegetation is the product of photosynthesis, vegetation respiration, as well as the vital activity of microorganisms in the soil. Because vegetations use sunlight and carbon dioxide *(CO_2)* during development, scientific ideas about the possibility of using CO_2 as fertilizer to accelerate their growth suggest the need to reevaluate its growth. In order to increase the productivity of land plots, all issues related to the application of fertilizers to the soil should be resolved after testing to determine the amount of this or that nutrient. The main nutrients are nitrogen *(N)*, phosphorus *(P)* and potassium *(K)*. Soil test calibration is performed to determine the level of correlation between the amount of crop grown and the amount of fertilizer applied to the soil. The issues of improving the test calibration procedure and optimizing the stages of crop production, taking into account the concentration of phosphorus in the soil and the amount of phosphorus fertilizer added to the soil, are also relevant. Since the amount of nitrogen in the leaves and gas exchange in plants and agrarian landscapes in general play an important role in the global circulation of carbon, nitrogen and water in terrestrial ecosystems, the development of remote sensing methods to accurately assess the condition of plants is one of the most important issues.

The Vegetation Condition Index (VCI), calculated on the basis of the Normalized Differential Vegetation Index (NDVI), is used as the main indicator in the ASIS FAO system. Spectral indicators related to photosynthetic active radiation are used in this index, and the data obtained on the basis of this index are reflected in the Earth Observation website. However, when vegetations have high levels of chlorophyll, there is a shortcoming, such as not taking into account the saturation effect of the NDVI index, and it is important to eliminate it. The phenological development of vegetation and other indicators of agrarian landscape should be studied as key factors in the effective management of ecosystems, as they are very important sources of information for monitoring based on information and measurement techniques, including the use of remote sensing (RS) methods. Thus, the implementation of the dissertation work on the development of new spectrophotometric methods of measuring the main indicators that characterize the dynamic features of the agrarian landscape is one of the main issues of modern times.

Objectives and tasks of the research:

The main purpose of the dissertation is to develop improved remote measurement and correction methods for assessing the condition parameters and seasonal dynamics of agrarian landscape components.

In order to achieve the main goal, the following issues were raised and resolved in the dissertation:

1. Identification of factors affecting the accuracy of remote measurement results of CO_2 flows on the soil surface and development of their compensation method.

2. Solution of the problem of optimization of productivity indicators of bioobjects (trees) and integrated measurement of CO_2 in all subareas, taking into account the functional relationship between the number of trees and measured morphometric indicators in all textured vegetation sub-areas.

3. Development of a method and algorithm for determining the amount of P in the soil based on the results of measurements of phosphorus in the soil and drainage water.

4. Development of a method for measuring the amount of chlorophyll in plant leaves based on the triangulation vegetation index.

5. Development of a correction methodology that allows to eliminate the error caused by the saturation effect of the NDVI.

6. Identify the functional characteristics of the new index, which has a wider range of functionalities similar to the Vegetation Health Index.

7. Development of a method of joint use of NDVI values in spectrophotometric assessment of soil erosion and new indices characterizing heavy metal pollution.

8. Development of correction procedures in determining the relationship between NDVI and LAI (chlorophyll content in leaves), presentation of the results of the classification of the agrarian landscape in the thematic layers of space images.

Research methods:

In order to solve the problems of the dissertation, mainly from the methods and techniques of atmosphere physics, soil science, botany, remote sensing, as well as elements of the theory of integral and differential calculus, provisions of the method of variation optimization, etc. was used. Model researches on the dissertation work were carried out, the obtained results were compared with theoretical provisions.

The main provisions of the defense:

1. Provision on the need to take into account the dependence of the results of remote measurements of CO_2 fluxes on the soil surface on soil and air temperature and a method of neutralizing the effect of air temperature by changing the flight altitude of PUA used as a carrier of thermal probing chamber.

2. New statistical-integrated measurement, which allows to make optimal measurements in textile fields, optimization of integrated measurement of bioindicators when determining the productivity of bioobjects and CO_2 concentration with a special camera.

3. Method and algorithm based on the results of measurements of phosphorus in the soil and drainage water to determine the amount of phosphorus in the soil.

4. Method for determination of chlorophyll content in plant leaves on the basis of measurement values of various triangulation vegetation indices and analytical expression for the calculation of concentration.

5. Correction methodology to eliminate errors caused by the saturation effect of NDVI in the assessment of stress conditions of plants.

6. The new index proposed as an analogue of the Vegetation Health Index, the principle of distinguishing the characteristics of humidity and drought, based on the management of its extreme value.

7. Joint measurement method that allows to determine the amount of organic matter in the spectrosonal study of the soil in order to eliminate the discrepancy accompanied by a decrease in the spectral reflection properties and increase the informativeness of the obtained results when the erosion level is low.

8. New indices characterizing the degree of contamination of the soil with heavy metals and an analytical expression of the relationship between the Nemero index and the geoaccumulation index.

Scientific novelty of the research:

1. A method has been proposed to neutralize the effect of air temperature on the results of remote measurements of CO_2 fluxes on the ground surface by changing the flight altitude of the UAV used as a carrier of a thermal sensing chamber.

2. Optimization of the integrated measurement method of tree productivity indicators and optimization of integrated measurement of bio-indicators in all subsectors during the measurement of CO_2 concentration by laser has been solved.

3. Based on the results of measurements of phosphorus in drainage water, a method and algorithm for determining the amount of phosphorus in the soil is proposed.

4. Based on the results of measuring the triangulation vegetation index in plants, a new method of measuring the amount of chlorophyll in leaves was proposed, and an analytical expression for the calculation of *CHL* concentration was obtained if the measured values of MTVI2 (modified triangulation vegetation index) were known.

5. It has been shown that the NDVI saturation event causes an inaccurate assessment of the stress state of the vegetation, and a correction methodology has been proposed to eliminate the resulting error.

6. A functional analogue of the Vegetation Health Index has been proposed, which proves that the management of the extreme value of this index has a limiting effect of the moisture factor, and that the absence of such management is preferable to the limiting role of sunlight.

7. In order to eliminate the shortcomings accompanied by a significant weakening of the spectral characteristics when the degree of soil erosion decreases and to strengthen the informativeness of the measurements, a general measurement method was proposed, which also determines the amount of organic matter in the soil.

8. The relationship equation between Nemero and Geoaccumulation indices used in the assessment of soil contamination with heavy metals was developed, two new indices reflecting the degree of pollution were proposed, and the exponential relationship between NDVI and LAI was determined.

The oretical and practical significance of the research:

1. The procedure of calibration of DOAS measuring devices measuring CO_2 concentration in the immediate vicinity of plant areas and the issue of optimizing the temperature dependence of CO_2 ecosystem flows are of great practical importance.

2. The possibility of eliminating errors in determining the concentration of phosphorus by means of remote sensing determines the conditions for the profitable conduct of agricultural activities in practice.

3. In order to maximize the average value of the vegetation share ratio, the cultivation of plants with a high NDVI index on land with a low value NDVIs index and vice versa in practice allows to obtain a high average share value in real NDVI with mixed pixels.

4. The algorithm for the implementation of the method of calibration of the remote measurement of the final contamination of composite areas with heavy metals, consisting of vegetated and non-vegetated areas, is of practical importance.

5. Mathematical expression of the dependence of the number of measurement points on the area of the test area allows the optimal selection of test sites in determining the degree of nitrogen and phosphorus contamination of the soil, thereby reducing the amount of data obtained.

6. The methodology of NDVI values correction, taking into account the effect of saturation of the NDVI index at high LAI values,

serves to ensure accuracy in determining the state parameters of the agrarian landscape.

Approbation and application:

The main provisions of the dissertation were discussed at the meetings of the Scientific and Technical Council of NASA and the Special Design Bureau of Space Engineering, as well as at the following scientific and technical conferences and forums: V International Scientific and Technical Conference, "Actual Problems of Physics" June, 2008; Scientific and practical conference "Khazarneftegazyatag-2016", Baku, December 22-23, 2016; Republican scientific-technical conference on "Youth and scientific innovations" dedicated to the 94th anniversary of national leader Heydar Aliyev, Baku, May 3-5, 2017; XII International scientific-practical conference "Agrarian Science and Agriculture", Russia "Altai State Agrarian University", Barnaul 2017; VIII Correspondence International Scientific-Practical Conference "Actual problems of ecology and labor protection", Kursk, May 12, 2016; IX International Scientific-Practical Conference "Actual problems of ecology and labor protection". South West State University Kursk, May 18, 2017; IX International scientific-practical conference "Actual problems of ecology and labor protection", 2017; "III International Scientific Conference of Young Researchers" dedicated to the 96th anniversary of national leader Heydar Aliyev, Baku, April 29-30, 2019.

The main results of the dissertation work were realized in the following scientific research works carried out at NASA in 2015-2020 with the direct participation of the applicant.

- Creation of electronic cartographic database of dynamics of landscape components of Nabran-Khachmaz region on the basis of spectrometric data (SRI report, code "Nabran", Baku, 2015, 51 pages creation, preparation of topographic and electronic maps).
- Electronic cartographic presentation of geoinformation modeling and dynamics of landscape elements of Guba-Gusar region on the

basis of space images (SRI report, code “Gusar”, Baku, 2016, 38 pages creation, preparation of topographic and electronic maps).

- Assessment of infrastructure components of Ismayilli region on the basis of geographic information systems and space images (SRI report, code “Infrastructure”, Baku, 2017, 39 pages - thematic processing of topographic maps and space images).

- Geoinformational assessment of the landscape structure of Shahbuz region on the basis of space images (SRI report, code “Shahbuz”, Baku, 2018, 40 pages-carrying out thematic processing procedures on space images).

-Evaluation of the state parameters of the landscape structure on the basis of remote sensing data (SRI report, code "Structure", Baku, 2019, 29 pages-carrying out thematic processing procedures on topographic map).

-Electronic cartographic presentation of landscape elements in different regions of Azerbaijan on the basis of GIS technologies and space data (SRI report, code “Element”, Baku, 2020, collection of page-archive materials).

Name of the organization where the dissertation work is performed.

The dissertation work was carried out at the “Space Monitoring Systems and Technologies” department of the Special Design Bureau of Space Equipment Design at NASA:

Personal presence of the author.

Defining research goals and directions, setting experiments, analysis of results were carried out with the direct participation of the author.

The volume and structure of the structural units of the dissertation separately.

The dissertation consists of an introduction, 4 chapters and 99 references.Chapter I of the dissertation consists of 49246 characters, Chapter II 35059 characters, Chapter III 48079 characters, Chapter IV 36803 characters.

A total of 192571 characters are commented on in the text, including the table of contents, introduction, main result, and list of references.

The **first chapter** of the dissertation is devoted to the development of methods for remote study of factors that increase the productivity of the agrarian landscape. The following compensation method for the effect of air temperature on the measured value of CO_2 flows over plant areas has been proposed.

1.The result of the measurement of CO_2 flows SSF_{CO_2} (carbon dioxide in unfinished soil) is presented as follows (humidity RH=const):

$$SSF_{CO_2} = f(T_{sup,} T_{air}).$$

Here T_{sup}-surface temperature, T_{air}-air temperature.

2. T_{sup} indicator is measured by means of a thermal measuring chamber installed in the PUA and the obtained results are expressed as follows:

$$T_{sup} = \varphi(H, T_{air}).$$

3. Taking into account the above expressions, the following was obtained:

$$SSF_{CO_2} = f(\varphi(H, T_{air}), T_{air}).$$

4. SSF_{CO_2} The solution to the problem of neutralizing the effect of T_{air} on the results of SSF_{CO_2} measurements is to choose the flight altitude (H) of the UAV in such a way as to minimize the effect of T_{air} on the measurement results. The issue of choosing the flight altitude of the UAV was studied, and the relevant formulas were presented:

The first chapter then deals with the optimization of integrated measurement of CO_2 concentration in agricultural areas. It has been assumed that a single textured field consists of n subtypes, that in each *i*-subtype taken Ni plants of i-th biotype grow and that i-th species emits as much carbon dioxide *(CO_2)* as *Bi*. Thus, the height of the *i*-bion type is determined by the functional dependence Bi = φ (Zí) between *Zi* and *Bi*, or the output signal of the measuring device is continuous as follows:

$$B_0 = \int_0^{N_{max}} N \cdot \varphi(Z) dN.$$

Then χ for the integral pointer of the texture

$$\chi = \int_0^{N_{max}} Z\ (N) dN = C\ ;\ C = \text{const}$$

condition is accepted, *φ(Z)* function is presented in the form of the first two limits of the Taylor series, and the unconditional variation optimization function is designed.The solution of the optimization problem based on the Euler method using the known relationship between B (object height) and GA (total first product) and RA (respiration of bio-objects) of the bioobject showed that the objective function takes an extreme value within the following solution:

$$Z(N) = \sqrt[b-1]{\frac{\lambda}{b \cdot k \cdot N}}\ .$$

It is shown that when b <1, *Z (N)* becomes an increasing function and the value of the objective function reaches a maximum. When b> 1, *Z(N)* becomes a decreasing function and the objective function reaches its minimum value.

At the end of the first chapter, the application of remote sensing methods to determine the concentration of phosphorus in the soil was considered, the algorithm of the proposed balance method consisted of the following stages

1. Determination of the concentration of *P* in the soil before irrigation of the field $C(P)_{SO}$.
2. Determination of $C(P)_{WO}$ of the concentration of *P* in irrigation water before field irrigation.
3. Determine the concentration of *P* in the soil $C(P)_{SO1}$ after irrigating the area.
4. Determination of $C(P)_{WO1}$ concentration of *P* in irrigation water after field irrigation.

5. $\Delta S = |C(P)so - C(P)so_1|$ given the absolute value of the difference and the ground Calculation of the total amount of *P* on the basis of sounding data $F_{1S}(P)$.

6. Calculation of the absolute value of the difference $\Delta w = |C(P)wo - C(P)wo1|$ and the total amount of *P* introduced into the soil before and after irrigationusing water sensing data $F_{1W}(P)$, at the end checking the $F_{1S}(P)=F_{1W}(P)$condition.

The **second chapter** of the dissertation is devoted to the development of indicators of the condition of the cultivated biomass and methods of studying the soil cover of the agrarian landscape. A new method for estimating the amount of ab chlorophyll in leaves has been proposed based on the results of remote determination of nitrogen in plants using triangulation vegetation indices. The highest correlation between the amount of *N* (nitrogen) in plant leaves and plant indices was obtained using MTVI2 (modified triangulation vegetation index) and was determined by SPAD spectrometry to determine the value of *CHL* (chlorophyll content in leaves). A method based on the interaction between *CHL* has been proposed.

Given the need to calibrate the device for each plant species to determine the *CHL* and *N* values, the linear dependence of the amount of *N* on the leaves of plants on the "SPAD indices" (a_1, a_2= const;) is shown. SPAD indices are indicators of the SPAD device. It is shown that the values of a_1 and a_2 are different for the plant species under study, and the dependence of the *CHL* on the SPAD indices can be approximated by the exponential function, which is the same for all plant species under study. The direct dependence of *CHL* on *N*.

$$CHL_i = A_i \cdot \exp\left[A_2 \left(\frac{N_i - a_2}{a_1} \right) \right] - A_3$$

as, N_i və MTVI2 regression equation between taken as

$$N_i = 26.901x^2 - 30.699x + 10.648 \, (x\text{=MTVI2}).$$

Thus, based on the measured values of the MTVI2 index, which allows to determine the amount of *CHL* in the leaves of plants

$$CHL_i = A_1 \cdot \exp\left[A_2 \cdot \left(\frac{26.901x^2 - 30.699x + 10.648 - a_2}{a_1}\right)\right] - A_3$$

dependence was obtained.

The second chapter then discusses the correction of VCI (Vegetation Condition Index) in the UN FAO ASIS system. The ASIS system used the Vegetation Health Index (VHI), calculated on the basis of the normalized difference vegetation index (NDVI), and the value of VHI<35 was taken as drought areas.

The VCI index, taken as the VHI index

$$VCI_i = \frac{100 \cdot (NDVI_i - NDVI_{\min})}{NDVI_{\max} - NDVI_{\min}}$$

defined as.

Here *VCI* – vegetation condition index and *TCI* - temperature condition index, *a* and *b* - weight ratios, $NDVI_i$ - NDVI price for ten days; Maximum wax value of NDVI in $NDVI_{max}$-vegetation index series; NDVI is the minimum value of NDVI in the vegetation index series.

It is assumed that the relative error of the VCI index due to saturation is greater than the relative error of the NDVI index, and it is shown that the NDVI index has a less saturation effect than the VCI.

The second chapter then deals with the development of a universal combined index of soil drought and moisture, as well as a simple and universal drought index. Given the existence of variable sign correlations between NDVI and LST in humid and dry climates, a method has been proposed to increase the reliability of the use of these indices for the purpose of monitoring the degree of soil dryness. As a functional analogue of the Vegetation Health Index (VHI)

$$TCIM = \alpha_1 \cdot NDVI + \alpha_2 LST, \quad \alpha_1 + \alpha_2 = 1$$

index is formed.

Markings f_1 (t) = NDVI (t) and f_2 (t) = LST (t) were adopted to increase the reliability of the use of the TCIM index in the zones of negative correlation between LST and NDVI. $f_1(t)$ and $f_2(t)$ are presented as the first three components of the Taylor series,

$$t_{opt} = -\frac{(\alpha_1 f_1' + \alpha_2 f_2')}{\alpha_1 f_1'' + \alpha_2 f_2''}$$

is such, It has been determined that TCIM has reached the extremes.

It is shown that there is a negative correlation between $f_1(t)$ and $f_2(t)$, $TCIM_{экс}$ extremal valuecan be calculated as

$$TCIM_{экс1} = \frac{f_1'^2}{f_1''}\left(\frac{1}{2} - \alpha_1\right).$$

Such, $\alpha_1 < \frac{1}{2}$ when the extreme is maximum, $\alpha_1 > \frac{1}{2}$ if there is a minimum.

It is also shown that when the correlation is positive, calculated as

$$TCIM_{ЭКС2} = -\frac{f_1'^2}{f_1''}.$$

It turned out that in the first case $TCIM_{exs.1}$ is a function of the weighting factor, and in the second case there is no such dependence. If the change in the value of α_1 is accompanied by a corresponding change in the extreme value of $TCIM_{ex}$, then the existence of moisture, which is a limiting factor, is suggested. At the same time, $\frac{f_1'^2}{f_1''}$ $t$he larger the stress, the stronger the limiting factor, i.e. there is a lack of moisture. If the change in the value of α_1 does not lead to a corresponding change in the extreme value of $TCIM_{exs}$ then it is assumed that there is no shortage of moisture, i.e. in this case the limiting factor is solar energy.

The **third chapter** of the dissertation is devoted to the problem of determining the degree of soil contamination by remote sensing methods. The method of spectral determination of soil erosion rate was carried out with the initial analysis of moisture content, plant

biomass and organic matter content in the soil, NDVI indicators. Figure 1 shows the absorption spectra of three types of soil, which differ in the content of organic and inorganic substances. From the presented spectral curves λ_1 = 1000 nm; λ_2 = 1400 nm; As it can be seen at wavelengths
λ_3 = 1900 nm, the composition of organic matter in the soil can be easily determined experimentally by performing spectral measurements in spectral zones with minimal reflection.

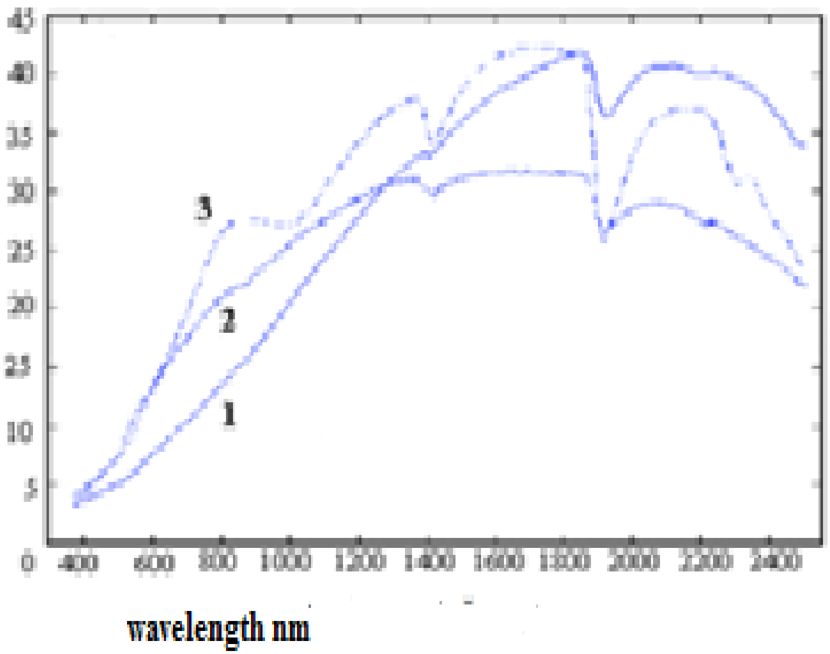

Fig.1. Spectra of reflection from three types of soil: 1-soil with high organic matter and low iron content, 2-soil with medium organic matter and iron content; 3-mesh with low organic content and high iron content

The proposed method for determining the degree of erosion of agricultural lands consisted of spectroscopic measurements at these wavelengths, as well as the determination of NDVI and joint analysis of the results. The use of NDVI to estimate green biomass was considered more appropriate and presented as a statistical model between NDVI and biomass.

Where *x*-NDVI; *y*-biomass, gr/m^2; *a,b*-are constant quantities depending on the type of field under consideration.

In order to optimize the measurement experiment, it was considered expedient to estimate the degree of erosion by determining the value of the NDVI index. *r*-correlation coefficient, *M(x, y)* correlation moment and σx, σy if the mean standard deviation as well as r = 0.46;
x = NDVI; y = SOM (total amount of organic matter in the soil)
σNDVI = 0,1; Given the values of, M = 0.5,

$$\sigma_{SOM} = \frac{M}{r \cdot \sigma_{NDVI}} = \frac{M}{0{,}046}$$

we get that. In the same expression we get σSOM = 10.9 T/ha, when in the considered model SOM = 200 tons / ha, the accuracy of SOM price determination was 5%. The results showed that the use of NDVI in the determination of SOM_s is quite accurate and it is expedient to use the proposed joint method of estimating the degree of erosion in agriculture.

At the end of the third chapter, new indicators for assessing the degree of contamination of agricultural lands with heavy metals were presented. Known geoaccumulation *(Igeo)* and Nemero indices *(N)* were used for this purpose. It is shown that these indices form following invariants.

$$\left(\frac{1{,}5 \cdot \sum_{i=1}^{n} 2^{I_{geo.i}}}{n \cdot N}\right)^2 + \left(\frac{1{,}5 \cdot 2^{I_{geo.max}}}{N}\right)^2 = 1.$$

The task on finding the optimal correlation between the parameters I_{geomax} and *N* was considered the following integral criterion was chosen as the criterion of optimality:

$$\gamma = \int_{0}^{N_{max}} \frac{2^{I_{geo.max}(N)}}{N} dN .$$

For this purpose, the appropriate constraint condition was selected, the unconditional variation optimization function was formed, and as a result of solving the optimization problem according to the Euler method, the following expression providing the minimum of the above functionality was obtained.

$$I_{geo.max}(N) = log_2 \left[\frac{|\lambda \cdot N|}{ln 2} \right].$$

The **fourth chapter** of the dissertation is devoted to the study of the seasonal dynamics of the agrarian landscape. Seasonal change diagrams were calculated based on vegetative indicators based on spectroradiometric data. In this regard, taking into account the saturation effect of NDVI at high values of the LAI index, the issue of developing a method of correction of this index was considered. An example of an experimental curve between NDVI and LAI for a pine plant is shown in Figure 2.

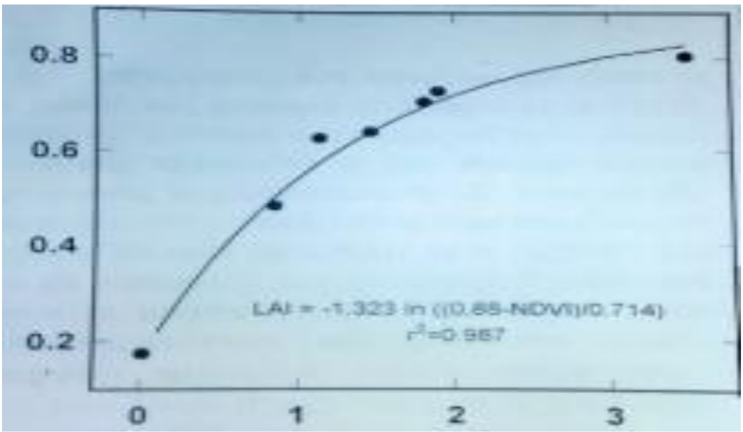

Fig.2. Experimental dependence between NDVI and LAI for pine plant

Taking into account the generalized (B, D, k_1 = const) relationship between NDVI and LAI, a correction method based on the following principle was proposed: NDVI index correction was performed by multiplying this index by the k-correction factor, the geometric meaning of correction by *k* factor

$$\int_0^{LAI_{\max}} [NDVI \cdot k - LAI] d(LAI) = 0$$

defined by the equation, the meaning of the geometric interpretation is shown in Figure 3. To calculate the coefficient K, the equation NDVI = 1-1 • exp [-0,1LAI] was obtained from the condition of the equality of the fields S_1 and S_2. If the condition LAImax = 10 is accepted, then k≈4 is obtained.

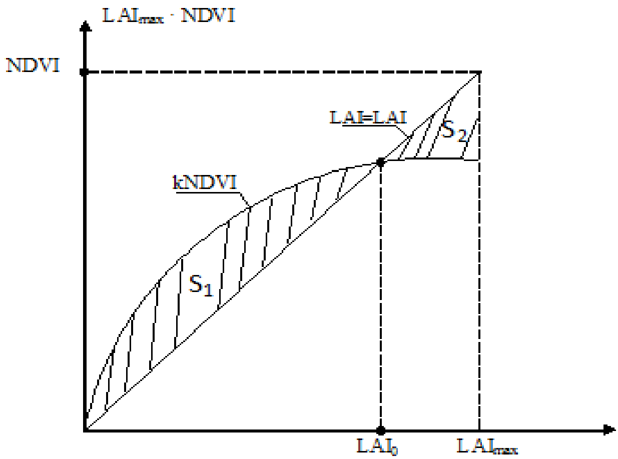

Fig. 3. Explanation of the method of correction of the saturation effect of the NDVI index

The fourth chapter then comments on the results of aerospace monitoring of the dynamics of the agrarian landscape components of the Nabran-Khachmaz region.

First of all, the research was conducted on 1: 100,000 scale maps of Khachmaz region. Recently, since it is not possible to obtain spectrophotometric data on the study area, archival data collected until the 1990s have been used. During the initial experiment, a relationship was established between phytometric parameters and spectrometric characteristics, in which case homogeneous agricultural objects were involved in the classification.

As a result of the research, it was found that the following factors had a serious impact on the condition of plant objects in the region after the abolition of the collective farm system.

- unplanned felling of forests and garden trees for domestic needs;
- annual change of the profile of agricultural crops depending on market conditions;
- rising groundwater level;
- changes in soil agrometeorological parameters under erosion, salinization and other natural and anthropogenic influences.

In connection with these factors, the classification of forest-plant objects on the basis of space images has been investigated as a topical issue.

At the end of the fourth chapter, a methodology for measuring the seasonal dynamics of spectrophotometric and phytometric characteristics of agricultural crops was developed. During the work, MAKA used a set of data collected by laboratory, field and low-orbit carriers of the spectral luminosity coefficient (SPA) of natural objects in 1985-1990 as the main base material. Measurements were made with a SF-18 laboratory spectrophotometer, a 22-channel spectrometer for field research and a 24-channel spectrometer mounted on a car tower and an MI-8 helicopter. A brief description of the type of land surface by seasons is given, NDVI index of forests and orchards is calculated, the obtained calculation results are presented in separate thematic layers of electronic map.

Main conclusion

1. Model calculations were carried out to neutralize the effect of air temperature on the results of remote measurements of CO_2 flows over soil and plant areas by changing the height of the carriers of the thermal measurement system, and an appropriate method was proposed.

2. The method of laser integrated measurement of productivity indicators in textured plant areas, as well as surface and underground concentrations of CO_2 was developed, the conditions for obtaining the optimal mode of measurements were determined taking into account the characteristics of bioindicators.

3. The procedure for calibration of DOAS measuring devices was proposed, the method and algorithm for determining the amount of phosphorus in the soil were developed.

4. Based on the remote sensing data of the visible area, a method for determining the chlorophyll parameters in plant leaves was proposed, and a correction procedure to eliminate the saturation effect of NDVI was developed.

5. A functional analogue of the Vegetation Health Index has been developed, and the relationship between its extreme features and drought and humidity factors has been identified.

6. In order to eliminate the shortcomings associated with a decrease in the reflection spectrum of the soil as the erosion level decreases and to increase the informativeness of the measurements, a general measurement method has been proposed, which includes the use of NDVI in addition to spectrosonal measurements.

7. The problem of optimal selection of test sites in determining the concentration of nitrogen and phosphorus in the soil was solved, two new indices were developed to determine the degree of contamination of the soil with heavy metals by establishing a correlation equation between Nemero and geoacumulation indices.

8. Exponential analytical form of dependence between NDVI and LAI was defined, classification results according to vegetation indices of landscape structure of Nabran-Khachmaz region on the basis of space images were presented in thematic layers of electronic maps.

The content of the dissertation is published in the following works:

1. Ширинзаде А.А., Алиева С.С. Новые показатели оценки степени загрязнения сельскохозяйственных земель тяжелыми металлами // “Известия НАКА”, Т. 18, 2015, № 4(18), с. 36-41.

2. Əliyeva S.S. Bitki sahələri üzərindəki CO_2 axınının miqdarının məsafədən təyini metodu //“XƏZƏRNEFTQAZYATAQ” Elmi-təcrübi konfransın materialları,Bakı , 2016. s. 561-565.

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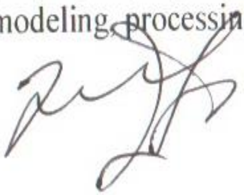

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