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ESTIMATION OF CO_2 OVER THE UKRAINE BASED ON GOSAT SATELLITE DATA

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Actuality. Large-scale spatial and temporal global and regional changes on Earth become an indisputable fact in recent decades. The climate is changing periodically within the time scales after each 10^1-10^8 years throughout the history of the Earth appearance. The initial scales correspond to the glacial periods happened in the past, but the actual scales – to the modern climate fluctuations [1, p. 80]. Fluctuations over the actual period of several hundred years were particularly well observed. The instrumental observation dimension in Ukraine pasts over 120 years. It is unlikely that within the recent years of the XXI century the global climate change caused by natural variability only. Since the second half of the twentieth century the human economic activity has reached the very high level. It provoked a strong unintended impact on climate change.

Nowadays, the fact of climate instability is becoming indisputable, but what reasons lead to this still remained controversial. For instance, according to the opinion of V.F. Loginov [2], raising of greenhouse gases volume provoke an increase of air temperature, but recent years the role of this factor is exaggerated. Actually, is considered that the climate warming is caused by the high influence of the world's oceans, which can regulate temperature through water vaporization process.

This study is focused on clarifying the anthropogenic conditions with the regional warming in Ukraine. The impetus to this research was provoked by the lack of common opinion, comprehensive analysis and an unified scientific approach to the climate change causes explaining, as well as presence of greenhouse effect opposite assessments and inertia of the climate system processes.

Taking into consideration that CO_2 is the main component of greenhouse gas, its concentration value in the atmosphere is one of the climate change factors, which requires constant and very accurate control.

The aim of the study: to determine the CO_2 content changes in the atmosphere over the Ukraine within 2010–2020 period.

Methods and materials. The CO_2 content in the atmosphere was measured based on the column layer average of CO_2 molar fractions using the TANSO-FTS spectrometer of the GOSAT satellite (Ibuki), Japan Space Agency. This approach is advisable to make such measurements.

Data from the GOSAT satellite were obtained from the official GOSAT Data Archive Service (GOSAT, 2020). The spatial resolution of space images is 2.5°, the file is provided in *h5* format. The official archive can provide the daily, monthly and annual data. The study was based on monthly data "L3 global CO_2 distribution". Work with these data in the processing space images program Erdas Imagine required translating them into '*img*' format.

The conversion technique consisted of several stapes: 1) Creating the '*grd*' file. For this purpose, the five rows were added, which contained the values of the columns and rows number, minimum and maximum coordinates in latitude and longitude, as well as other information corresponded to the CO_2 concentration values. 2) Convert the file from '*grd*' to '*img*' format. The conversion was performed using the Import function of Erdas Imagine. 3) Geometric correction of the obtained image, which was performed using the Geometric Correction function of the Erdas Imagine program and converted into the *Geographic* coordinate degrees system. 4) Defining the contour of the Ukraine. Considering the Subset function of the Erdas Imagine program, the Ukraine was selected in the space image using

the vector data of "*Ukraine 500*". Based on the GOSAT satellite data, the CO_2 concentration was determined, converted according to this approach and the average values were estimated for each year.

Results. The analysis of CO_2 concentration values changes over the Ukraine within the 2010 – 2020 was carried out (fig. 1 *a*). During the reviewed period the annual average of CO_2 concentration increased to 2.3 ppm.

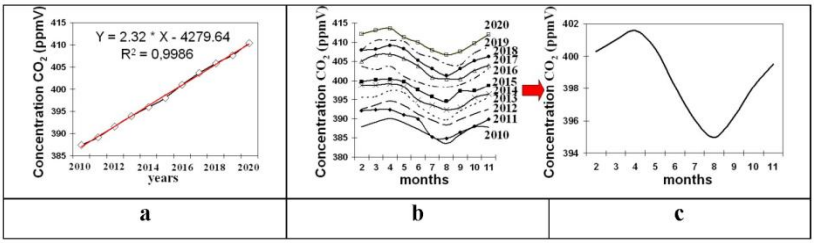

Figure 1. The average of annual CO_2 concentration values changes in Ukraine from 2010 to 2020 according to the GOSAT satellite data

The graph shows the linear trend of coincidence between the correlation coefficient R^2 = 0,9986 and the CO_2 concentration distribution over the years. The CO_2 concentration changes analyzed over the 11 years and its distribution nature by the months is given on Fig. 1*b*. The results analysis demonstrated that each year the distribution of CO_2 concentration has the "sinusoidal" character that corresponds to the general trends of CO_2 concentration increasing in the atmosphere. To establish the general nature of the CO_2 concentration distribution, its average monthly concentration values were estimated for the 2010 – 2020 period (Fig. 1 *c*). The distribution obtained for 11 years, clearly reflects the annual course of CO_2 concentration and permits to determine the months, where the maximum (August) and minimum (April) of CO_2 absorption occurs. Such fluctuations of the CO_2 concentration distribution over the Ukraine are determined by vegetation. Therefore, it was observed that due to the photosynthesis, the CO_2 content in the atmosphere decreases from May to August and increases from September to April. The average difference between the maximum and minimum of CO_2 concentration absorption is 7 ppm. Considering that the CO_2 acts as the "core" component of greenhouse gas according to the Paris Protocol, the interest regarding its concentration in the atmospheric masses over each country is permanently increase. The assessment of CO_2 concentration distribution over the Ukraine is presented on Fig. 2.

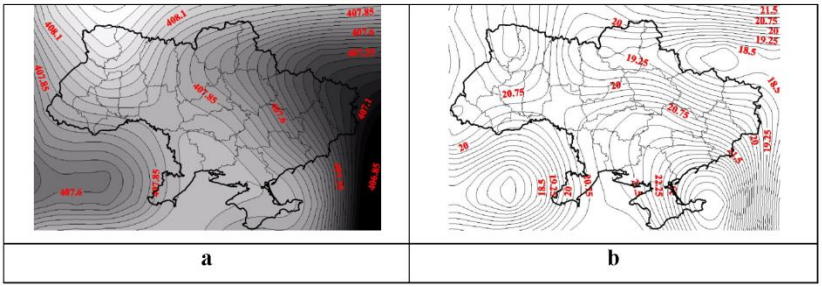

Figure 2. The map of CO_2 concentration distribution according to the GOSAT satellite data for 2018 over the Ukraine: *a* – annual average values, *b* – local component of the average values

Mathematical processing of the CO_2 concentration allowed to isolate the local component, which directly corresponded to the real characteristics of the territory (Fig. 2.*b*). There are 2 maximum values over the eastern region, attributed to the territory with the location of main industrial enterprises. One more maximum is observed over the western part of Ukraine, which could be explained by air masses transboundary transfer from the European countries.

Based on the spatial-temporal estimation obtained from the correlation (*Y = 2,328X – 4279,64*), where *X is years*, and *Y is the CO_2 concentration value*, it is possible to forecast the next 5 years until 2025 with the high reliability $R^2 = 0,9986$. (table 1).

Table 1

Forecast values of CO_2 concentration changes over the Ukraine until 2025

Nr.	Year	CO_2 Concentration Value Average (ppmV)
1	2021	412,57
2	2022	414,89
3	2023	417,21
4	2024	419,54
5	2025	421,86

In [3, 4] the trend of CO_2 concentration and temperatures distribution was compared. The results showed that the CO_2 concentration values in the atmosphere and air temperature (^oC) are in a direct correlation. It means

that CO_2 concentration increasing (Fig. 1 *a*) will affect the increasing of the regional air temperature.

Conclusions. To predict the possible climate change, the continuous operational monitoring of CO_2 concentrations in atmosphere is required. Such monitoring has to be carried out with application of the remote sensing data, which can help to address the potential threats resulted by the negative effects of climate change to the environment and society.

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