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## ABOUT DIGITAL FILTRATION IN THE TASKS OF GHG CONCENTRATION REDUCTION

**Abstract.** The process of global warming is currently accelerated due to human actions. Burning fossil fuel, developing industry and transport, intensive land use and landcover change became the reasons for carbon dioxide (CO<sub>2</sub>) concentration increase of up to 420 ppm nowadays in comparison to 380 ppm in the preindustrial period.

To solve the problem of CO<sub>2</sub> concentration reduction is important for the preservation of all habitable areas on Earth. The first step for developing of effective solution is to identify areas with high and low CO<sub>2</sub> concentrations. We propose to apply digital filtration methods for the localisation of these areas and the identification of their borders.

**Keywords:** Greenhouse gases (GHG); CO<sub>2</sub> concentrations; Laplacian.

### 1. INTRODUCTION

One of the most important problems for humanity today is global warming. It is scientifically proved [1] that greenhouse gas (GHG) concentration increase is mainly responsible for that. The most dangerous impact comes from carbon dioxide (CO<sub>2</sub>), which we place in the focus of our research. The global warming leads to climate change and an increase in different types of weather and climate extremes, their power and frequency [2].

The main natural methods for atmospheric CO<sub>2</sub> concentration reduction in the atmosphere are afforestation and reforestation. This will increase the amount of green biomass, which fixes the atmospheric CO<sub>2</sub>. However, these methods have some limitations. For example, the areas available for growing new and recovering old forests depend on the climate conditions and space limitations. Therefore, the problem of efficient land use and CO<sub>2</sub> fixation with vegetation is urgent.

The efficiency of ecosystem CO<sub>2</sub> fixation can be improved by vegetation variability. The search for necessary species combinations is problematic and elongated. The problems set contains the vegetation features, the local environment and the internal and external biophysical ecosystem processes. The same species combinations in different environmental conditions will have different properties. This is caused by different reactions of the species to even slight environmental changes - soil chemistry and humidity, soil type, local landscape, location, etc.

In the process of evolution, species went through selection and form species combinations. This explains a further investigation of the current ecosystems' features and their efficiency analysis.

**The problem statement.** To reach the goals, we need to identify ecosystems with effective CO<sub>2</sub> fixation. The identification process is based on information about spatial changes in atmospheric CO<sub>2</sub> concentrations (CDC). We hypothesize that *the spatial changes of atmospheric CDC depend on the ecosystem's CO<sub>2</sub> fixation ability* (H1). The alternative null hypothesis (H0) is *spatial changes of atmospheric CDC are independent of ecosystem features*.

We plan to find species combinations, which have the highest CO<sub>2</sub> fixation level for determined conditions. In this case, "combination" means a set of phenotypes and their ratio.

Our goal is to define information tools for the first step of research - ecosystem localisation. For this purpose, we propose a digital filtration method.

## 2. THE THEORETICAL BACKGROUNDS

Global warming is caused by the accumulation of GHG in the Earth's atmosphere, related to human activity results. The natural balance of atmosphere gases changes due to the pollution made by industrial production. About Carbon Dioxide, the balance change is described by the Carbon Cycle [3] breach. The previously formed balance of natural CO<sub>2</sub> sinks and sources was broken by industrial objects. The greatest impact is made by fossil fuel burning, cement production and forest reduction. The most dangerous is that a small amount of industrial pollution leads to non-proportional disturbance in the Earth's ecology. The fact is that natural CO<sub>2</sub> injection is more oversized than an industrial one, but the last was a guide to increasing more than 40 ppm CO<sub>2</sub> concentration from the 380 ppm in the pre-industrial period. This may be caused, in particular, by atmosphere chemistry structure changes with new components from industry which are absent in nature.

However, Earth's atmosphere is a closed system with specific chemical and physical characteristics. For example, the atmosphere temperature does not change instantly under the Sun radiation in the morning according to thermodynamics law. The gas injection process is inertial too. The factory's chimneys do not immediately change the concentration of CO<sub>2</sub>, for example, at any part of the atmosphere of the planet. This process is described by the diffusion law and additional features of the environment.

These pointed features make it possible to see a relatively small area of any ecosystem in the time moment as a closed-volume system with temporary constant characteristics. According to this, the CO<sub>2</sub> balance (*CDB*), for example, in such systems may be described as:

$$CDB = Env_{in} - Env_{out} + \sum Int_{src_k} - \sum Int_{sink_l} \quad (1)$$

where,  $Env_{in}$  – the intensity of the CO<sub>2</sub> injection from the external environment,  $Env_{out}$  – the intensity of the CO<sub>2</sub> removal to the external environment,  $Int_{src_k}$  – the intensity of the internal  $k$ -th CO<sub>2</sub> source,  $Int_{sink_l}$  – the intensity of the internal  $l$ -th CO<sub>2</sub> sink.

For the small neighbouring ecosystems' areas, an external environment impacts we can take as equal based on the spatial coherence. The difference in *CDB* for neighbouring ecosystems will be defined by the difference in ecosystems' internal features only:

$$\begin{aligned} CDB^1 - CDB^2 &= (Env_{in} - Env_{out} + \sum Int_{src_{k1}} - \sum Int_{sink_{l1}}) \\ &\quad - (Env_{in} - Env_{out} + \sum Int_{src_{k2}} - \sum Int_{sink_{l2}}) \\ &= \sum Int_{src_{k1}} - \sum Int_{sink_{l1}} + \sum Int_{sink_{k2}} - \sum Int_{src_{l2}} \end{aligned} \quad (2)$$

So mathematically, the difference in the effectiveness between the neighbouring ecosystems is explained by the greater difference in the total amounts of injected (by sources) and fixed (by sinks) amounts of CO<sub>2</sub> which are displayed by  $CDB^1$  and  $CDB^2$  variables. This property may be used for the ecosystem' CO<sub>2</sub> fixation effectiveness comparison and corresponding area searching.

An implementation of this proposition coincides with a processing by digital Laplacian filter [4]. The better effect has the filter with the next structure (3):

$$Lp = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix} \quad (3)$$

In reality, the ecosystem's CO<sub>2</sub> balance at the moment can be shown by the CDC, which is directly related to the total amount of CO<sub>2</sub> in the volume unit of the atmosphere. So, the data about CDC can be used as source data for the subsequent analysis. According to this, the processing by the filter (3) is described as:

$$Lp_{r,c} = \begin{bmatrix} (cdc_{r,c} - cdc_{r-1,c-1}) & +(cdc_{r,c} - cdc_{r-1,c}) & +(cdc_{r,c} - cdc_{r-1,c+1}) \\ +(cdc_{r,c} - cdc_{r,c-1}) & +0 & +(cdc_{r,c} - cdc_{r,c+1}) \\ +(cdc_{r,c} - cdc_{r+1,c-1}) & +(cdc_{r,c} - cdc_{r+1,c}) & +(cdc_{r,c} - cdc_{r+1,c+1}) \end{bmatrix} \quad (4)$$

#### 4. THE RESULTS AND DISCUSSION

To check and test the proposed approach, we used the CDC [5] and CO<sub>2</sub> fire emission fluxes [6] data. Examples of input CDC data (fig.1). fire fluxes (fig.2) and results (fig.3) of Laplacian processing are shown below.

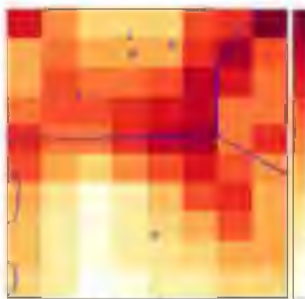


Figure 1. CDC spatial distribution

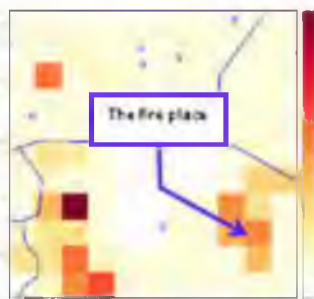


Figure 2. CO<sub>2</sub> fire fluxes spatial distribution



Figure 3. Spatial distribution after Laplacian

#### CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

The obtained results pointed to the closed location of the calculated place of CO<sub>2</sub> source to the actual fireplace location. An accuracy of received results related to the source datasets' resolutions in the first order. Generally, the digital Laplacian filters can be used in tasks of GHG reduction for the sources' and sinks' location detection.

#### REFERENCES

1. Carbon stocks, fluxes and the land sector (2022) Forest Carbon and Climate Program. Available at: <https://www.canr.msu.edu/news/carbon-fluxes-and-carbon-stocks> (Accessed: 13 November 2023).
2. Smith, M.D. (2011) 'The ecological role of climate extremes: Current understanding and future prospects', *Journal of Ecology*, 99(3), pp. 651–655. doi:10.1111/j.1365-2745.2011.01833.x.
3. Carbon stocks, fluxes and the land sector (2022) Forest Carbon and Climate Program. Available at: <https://www.canr.msu.edu/news/carbon-fluxes-and-carbon-stocks> (Accessed: 13 November 2023).
4. Imagemagick examples -- convolution of images (no date) Convolution of Images -- ImageMagick Examples. Available at: <https://www.imagemagick.org/Usage/convolve/> (Accessed: 13 November 2023).

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