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Evolution of the global termperature

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ABSTRACT: There is a discrepancy in the understanding of some aspects of climate change disseminated by the media and the results of research within scientific programs and projects of NASA and other organizations. According to the media, climate change is the main danger for humanity, a change in the temperature of the planet by 2°C is a red line, above which the planet heating will occur irreversibly, and the main cause of the warming is carbon dioxide emissions resulted from the burning of fossil fuels. Here we demonstrate that these statements are kind of a sequence of modern myths that are not actually supported by scientific validation. To explain that we present an analysis of the results of long-term scientific programs and projects, as well as the carbon cycle between the Earth and its atmosphere, which are inserted in the global model of evolution of the Earth's thermal state. The analysis of the measurements shows that a sharp change in the evolution of the Earth's thermal state occurred starting from the eighties of the 20th century, when the temperature increase approximately was of 1°C in 60 years. In the past, the Earth's temperature varied in a corridor of about 20°C. The carbon equilibrium between the Earth and the atmosphere is carried out by photosynthesis, on the one hand, and by plants breathing and rotting, on the other hand. The flux of carbon into the atmosphere through the burning of fossil fuels increases the latter flux by 5%. However, during the industrial period (approximately 300 years), the anthropogenic amount of carbon in the atmosphere and on the Earth's surface has increased by one and a half times. The increase in the concentration of carbon dioxide in the atmosphere during the industrial period caused an increase in crop yields by about one and a half times due to increased the photosynthesis rate, which is for the benefit of humanity, and under contemporary conditions, this growth does not affect human health. Unfortunately, the dissemination by the media of a false cause of climate change can lead to an incorrect production development strategy. In particular, it is shown that the widely advertised hydrogen energetics based on the replacement of natural gas with hydrogen causes great risks in mass use.

Keywords: climate change, global temperature, energy balance of the Earth

1. INTRODUCTION

The mass media convince the population that one of the main problems of humanity at present is climate change and thereby create global interest in this problem. Some aspects of this problem are being investigated within the framework of long-term atmospheric programs, more than half of which relate to NASA. The results of these programs allow one to reliably answer important questions. However, the state of the problem, disseminated by the mass media, only partially takes into account these results. We will present some aspects of this in the form of a series of myths. Let's present the main ones.

Myth 1. The warming of the planet poses a great danger to humanity. At the same time, an increase in global temperature by 2°C will lead to an irreversible subsequent increase in temperature. In particular, this is indicated in the Paris Climate Agreemen 2015 [1].

Myth 2. The observed increase in global temperature over time is determined by an increase in the concentration of atmospheric carbon dioxide injected in the atmosphere as a result of burning of fossil fuels.

Myth 3. In order to decrease injection of carbon dioxide in the atmosphere, it is necessary, as far as possible, to abandon carbon energetics, replacing methane with hydrogen in gas power plants and in everyday life.

The purpose of this article is to analyze the current state of the problem of global temperature growth, which

takes as a basis the measurements of atmospheric parameters. as well as the analysis the problem of atmospheric carbon dioxide.

2. CHANGES IN THE EARTH'S TEMPERATURE

The evolution of global temperature can be represented by considering averages over different spans of time of long-term records of temperature measurements. The analysis of the obtained data is complicated by large fluctuations, and in order to reduce them from degrees to tenths of a degree, if we take as a basis not the average local temperatures, but the difference in local temperatures for a given point of the globe and a certain daily season time, but in different years [2]. Based on this, a number of organizations have done a lot of work on the evolution of global temperature since the second half of the 19th century, where weather stations have existed.

This algorithm was used within the framework of the project of the Gottard Institute for Space Studies [3] which uses data of six thousand of weather stations in the 19th century, and now its number is almost two thousand, while satellite measurements give the main contribution to the contemporary determination of the global temperature. Fig.1 contains some results for evolution of the global temperature obtained on the basis of the above algorithm.

As it follows from data of Fig.1, the fluctuations in the global temperature are approximately 0.2K, and the trend of temperature evolution can be obtained by averaging over at least ten years. Fig.2 contains the character of global temperature evolution if its fluctuations are removed. According to the data in Fig.2, the current change in global temperature is of a threshold character. This means that the rise in global temperature is determined by a mechanism that was previously absent. One can expect that this is due to the formation of micron and submicron aerosols of a certain type in the atmosphere.

On the basis of the above data we have for the rate of growth of the global temperature

$$\frac{d\Delta T}{dt} = (17 \pm 3) mK/yr, \tag{2.1}$$

One can see than that corresponds to increase of the global temperature by 1^oC approximately for 60 years.

But this growth occurs unevenly across the globe, which we will get by examining this value for different regions of the globe. Dividing the Earth's surface into the northern and southern hemispheres, as well as land and oceans, we compare in Table 1 partial temperature changes with respect to the average global temperature in the 20th century. From data of Table 1 it follows that the greatest warming of the Earth's surface occurs on land in the northern hemisphere. This is indirect evidence that these changes occur as a result of the human activity. In addition, these changes result in a non-monotonous manner, and the value of fluctuations in the process of heating the Earth reaches 0.2^oC.

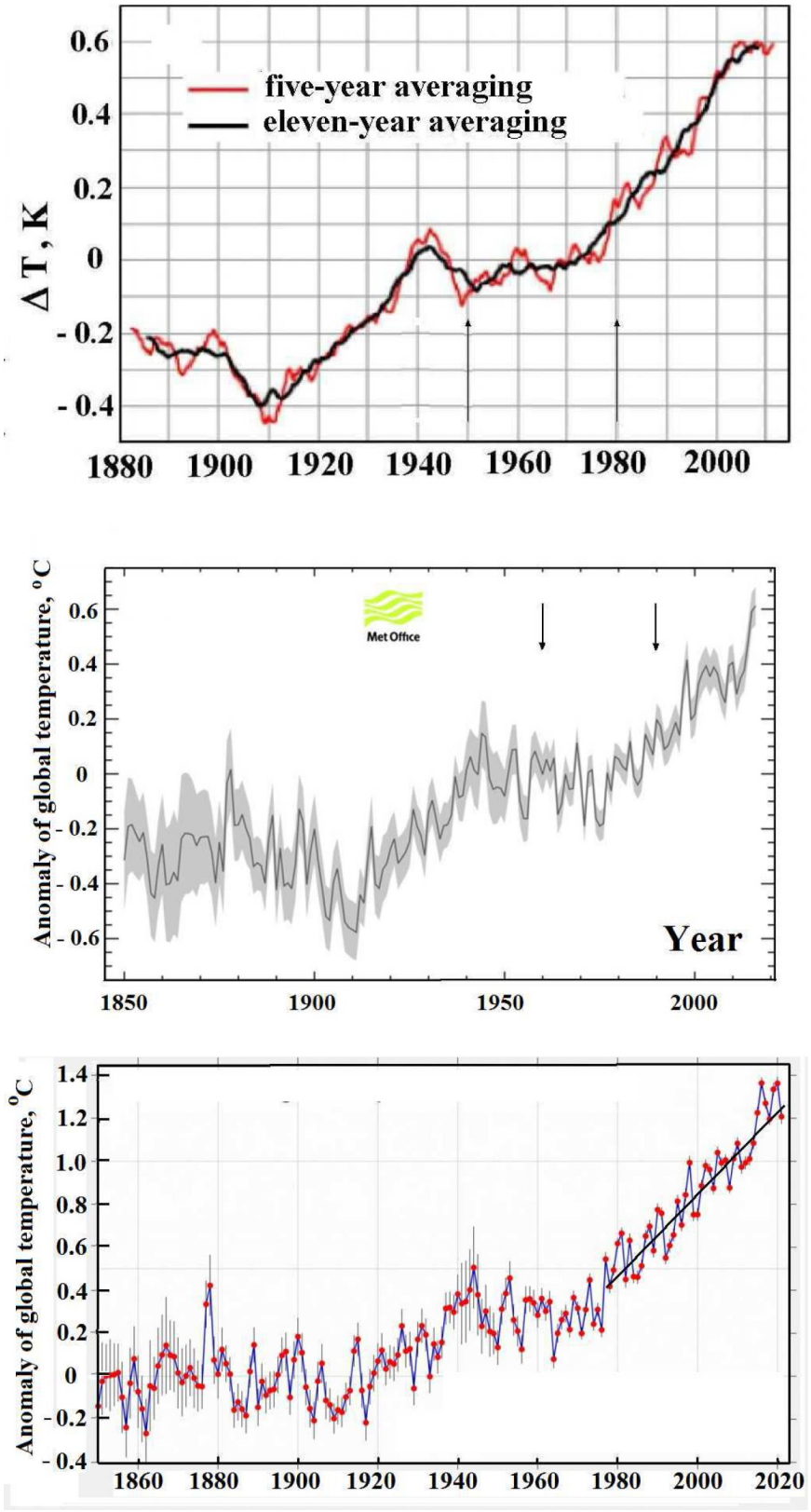

Figure 1: Anomalies in the global temperature obtained on the basis of data from weather stations. Results of the Goddard Institute (USA) [4], Hadley center (UK) [5, 6] (b), and Berkeley laboratory (USA) [7] (c). The temperature anomalies in (a) counts from the average value in 1951-1980 marked by arrows.

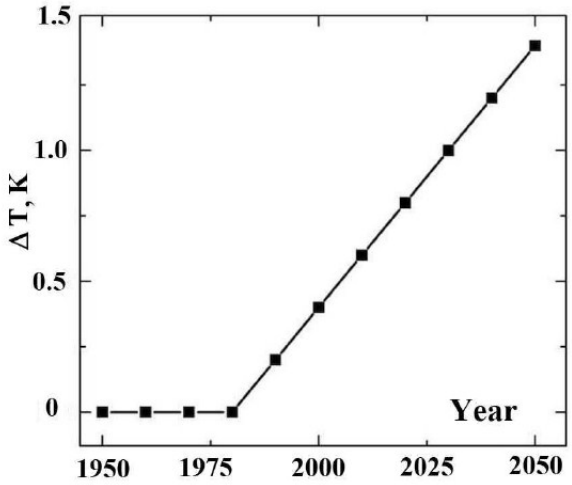

Figure 2: Simplified character of evolution of the global temperature last time constructing on the basis of data of Fig.1 in neglecting the fluctuations [8].

Table 1. Change in the global temperature with respect to the average temperature of the Earth in the 20th century [9, 10, 11]. The temperature is expressed in ºC.

Region	Time	Land	Ocean	Land + Ocean
Northern Hemisphere	May 2018	1.27	0.69	0.91
	May 2019	1.25	0.81	0.93
	Jan-Dec. 2021	1.54	0.89	1.09
	Jan-July 2022	1.54	0.81	1.09
Southern Hemisphere	May 2018	1.06	0.54	0.62
	May 2019	1.13	0.69	0.77
	Jan-Dec. 2021	0.86	0.54	0.59
	Jan-July 2022	0.88	0.57	0.62
Total Earth's surface	May 2018	1.21	0.60	0.77
	May 2019	1.16	0.73	0.85
	Jan-Dec. 2021	1.35	0.65	0.84
	Jan-July 2022	1.36	0.67	0.86

As it follows from the data in Table.2, the observed increase in the global temperature cannot be related to the atmosphere due to mixing of air over land and ocean.

For large time scales in past, it is possible to determine only the change in the local temperature on the basis of isotopic methods. Summing up these data shows that the characteristic temperature in the last billion years is in the corridor of about 20 K [12]. The hottest planet was during the Eocene approximately 50 million years ago, and the temperature near the North pole at the beginning of the Eocene period [13] was (23-24)ºC [14, 15], and the temperature at the South pole was (3-5)ºC [16].

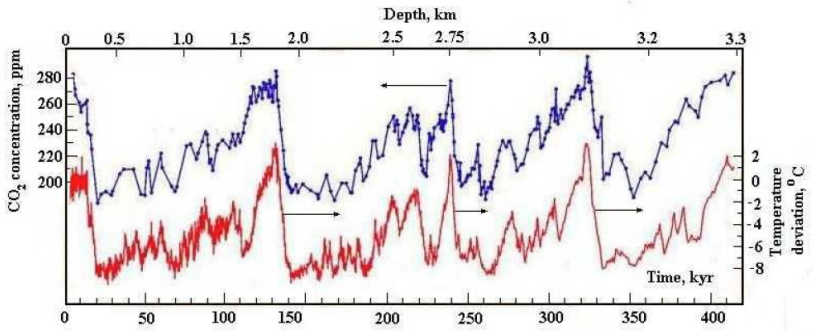

Figure 3: Evolution of the Earth's surface temperature and the atmospheric carbon dioxide concentration in past in the Antarctic region, as it follows from the analysis of ice deposits in Antarctica near the Vostok and Dome C weather stations [18, 19].

The most detailed study of climate change in the past was fulfilled within the framework of the EPICA (European Project for Ice Coring in Antarctica) project [17] at the beginning of this century that consisted in the analysis of air bubbles preserved in ice pits. These bubbles were extracted from different depths and correspond to certain times. The time dependence of the temperature and carbon dioxide concentration is represented in Fig.3 which is obtained on the basis of the isotope analysis of bubbles inside ice.

One can see from Fig.3 a slow cooling of atmospheric air with the rate of the order of 10^{-4} *K/yr*, and subsequently fast heating. The glacial period is approximately 100.000 years, and this character of evolution of the Earth's thermal state is observed 1 million years, at least. According to the data of Fig.3, the concentration of atmospheric carbon dioxide in the course of glacial cycles of the half a million years has varied from 172 to 280 ppm [18, 19]. For comparison, the current concentration of atmospheric carbon dioxide molecules is now approximately 416 ppm according to measurements from the Mauna Loa observation [20, 21].

Characterizing the state of the Earth and atmosphere by the albedo, one can see that the transition between warm and cold state in the course of the glacial period leads to variation of the albedo of the atmosphere from 0.25 to 0.22, whereas the surface albedo varies from 0.11 to 0.36 [22]. For comparison, the albedo of an absolutely black body is 0, and ice is 0.84. At the cold stage of the glacial period, ice covers about 40% of the Earth's surface. One can explain this character of processes in the course of the glacial cycle by a small penetration of water into the hot layers of the Earth during a cold time of the glacial cycle. This causes an increased eruption of volcanoes, which changes the optical properties of the Earth's surface and atmosphere [22]. It is significant that during a cold time of the glacial cycle, only a part of the Earth's surface is covered with ice, which preserved life on Earth in this time. In addition, the above investigations show that changes in the Earth's temperature during its evolution significantly exceed its maximum heating of 2°C, which is announced by the mass media. This shows the inconsistency of the first myth formulated in the Introduction.

3. EARTH'S ENERGY BALANCE AND ATMOSPHERIC RADIATION

The thermal state of the Earth is determined by energy processes involving the Earth and its atmosphere. Under the influence of these energy fluxes, an energetic equilibrium is established between the Earth and the atmosphere. Considering the global energetic equilibrium that has been maintained for tens and hundreds of years, we introduce the average energy fluxes, each of which represents the power transferred through this channel divided by the area of the Earth's surface. The most intense energy fluxes, expressed inW/m^2, are shown in Fig.4. For comparison, the total specific power of the world production is equal $0.04W/m^2$.

The energy fluxes of Fig.4 are statistical averaging over the data of five sources including data of NASA and WMO. The accuracy of the averaged data is no better than $1W/m^2$. The beginning of these energetic processes is solar radiation in the visible range spectrum which penetrates in the Earth's atmosphere. Fluctuations in the intensity of solar radiation and its changes over the past three hundred years are small compared to the accuracy of determining of this value.

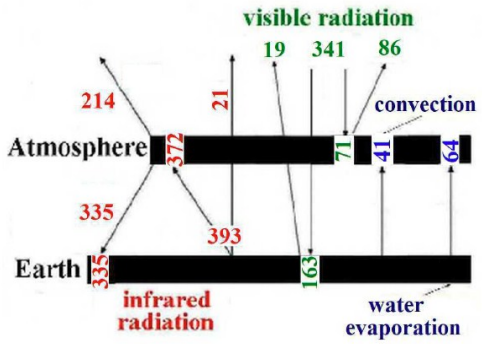

Figure 4: Expressed in W/m^2 average energy fluxes [8] which establish the energetic equilibrium between the Earth and its atmosphere. Absorbed energy fluxes are given inside corresponding rectangulars, consumed energy fluxes are indicated near arrows [8].

Table 2. Average radiative fluxes and contributions of radiative atmospheric components (greenhouse components) to the radiative flux created in the atmosphere and directed to the Earth [23].

Component	Flux, W/m^2	Portion, %
H_2O-molecules	166	51
H_2O-droplets	96	29
CO_2-molecules	58	18
CH_4-molecules	4	1
N_2O-molecules	3	1

Currently, the parameters of infrared radiation of the atmosphere due to the molecules contained in it can be calculated on the basis of spectroscopic data from the HITRAN base [24, 25, 26]. Such calculations are based on the altitude profiles of densities of greenhouse components and temperature profile. Table 2 contains the radiative fluxes from greenhouse components of the atmosphere according to evaluations [23]. This give a representation about the role of some greenhouse components in the atmospheric emission.

A change in radiative fluxes due to a change in the concentration of greenhouse atmospheric components is of interest, especially, in the case of atmospheric carbon dioxide. In accordance with Kirchhoff's law, there is a fundamental difference in the change of the radiation flux in cases of a single-component and multicomponent systems [23]. Indeed, according to Kirchhoff's law, the emitter is also an absorber at the same time. In the case of a flat layer consisting of an equilibrium one-component gas with a slightly varying temperature along its altitude, a change in the concentration of this component leads to a change in the effective radiation temperature only due to injected molecules, whereas in a multicomponent gas, along with this, other components absorb the radiation of injected molecules. In other words, emission of water molecules and water microdroplets of clouds is absorbed partially by injected CO_2 molecules.

This effect is determined by overlapping of absorption spectra of CO_2 molecules with spectra of atmospheric water molecules and water microdroplets. Such information is contained in the HITRAN base [24, 25, 26] that allows one to determine reliably the change in the radiative flux of the atmosphere as a result of the injection of an additional amount of carbon dioxide and divide increasing in the radiative flux due to radiation of injected carbon dioxide molecules with decreasing in the radiative flux as a result of absorption the radiative flux due to water molecules and clouds by injected CO_2 molecules. The second effect is ignored in climate models [27, 28]. This leads to an overestimation of the change in the total radiation flux by five times [29].

Taking into account that the main greenhouse components of the atmosphere are water and carbon dioxide molecules, as well as clouds, we present the contradiction under consideration between climate models and measurement results for changes in global temperature as a result of an increase in carbon dioxide concentration in the mathematical form. Following the "line-by-line" [30] model, which takes into account the spectral features of atmospheric radiation, we introduce changes in radiation fluxes $\Delta J_\omega(H_2O),\ \Delta J_\omega(CO_2)$ and $\Delta J_\omega(cl)$, which represent changes in radiation fluxes for a given frequency ω created by $H_2O,\ CO_2$ molecules and clouds, respectively, as a result of changes in the concentration of carbon dioxide molecules. From the conservation law we have for change of the total radiation flux ΔJ_ω of the atmosphere

$$\Delta J_\omega = \Delta J_\omega(CO_2) + \Delta J_\omega(H_2O) + \Delta J_\omega(cl), \tag{3.1}$$

which is true both for partial fluxes at a certain frequency and for radiation fluxes integrated by frequencies.

The simplification used in universal climate models consists in the neglect of the second and third terms on the right side of the equation (3.1). This corresponds to the neglect of Kirchhoff's law and, for real spectra of greenhouse components in the atmosphere, leads to an increase in the global temperature change by a factor of five. The contribution to the change in global temperature (3.1) due to the increase in the concentration of atmospheric carbon dioxide is approximately 30%. Of course, the considered error of climate models can be eliminated by introducing into them the spectral characteristics of the atmosphere in accordance with the general principles of atmospheric radiation [31, 32, 33, 34], as well as taking into account the spectral parameters of the atmosphere. [24, 25, 26].

The mistake of universal climate models follows from the behavior of the value η_ω which is defined as

$$\eta_\omega = \frac{\Delta J_c(\omega)}{\Delta J_\downarrow(\omega)} \tag{3.2}$$

and is presented in Fig.5. An average of this value over the spectrum shows that universal climate models overestimate the growth rate of the global temperature by a factor of five.

Thus, the warming of the planet due to the greenhouse effect associated with an increase in the concentration of carbon dioxide in the atmosphere is a secondary effect in an increase of the global temperature that is observed in recent decades. This rejects the second myth presented in Introduction. According to this myth, an increase in the global temperature is

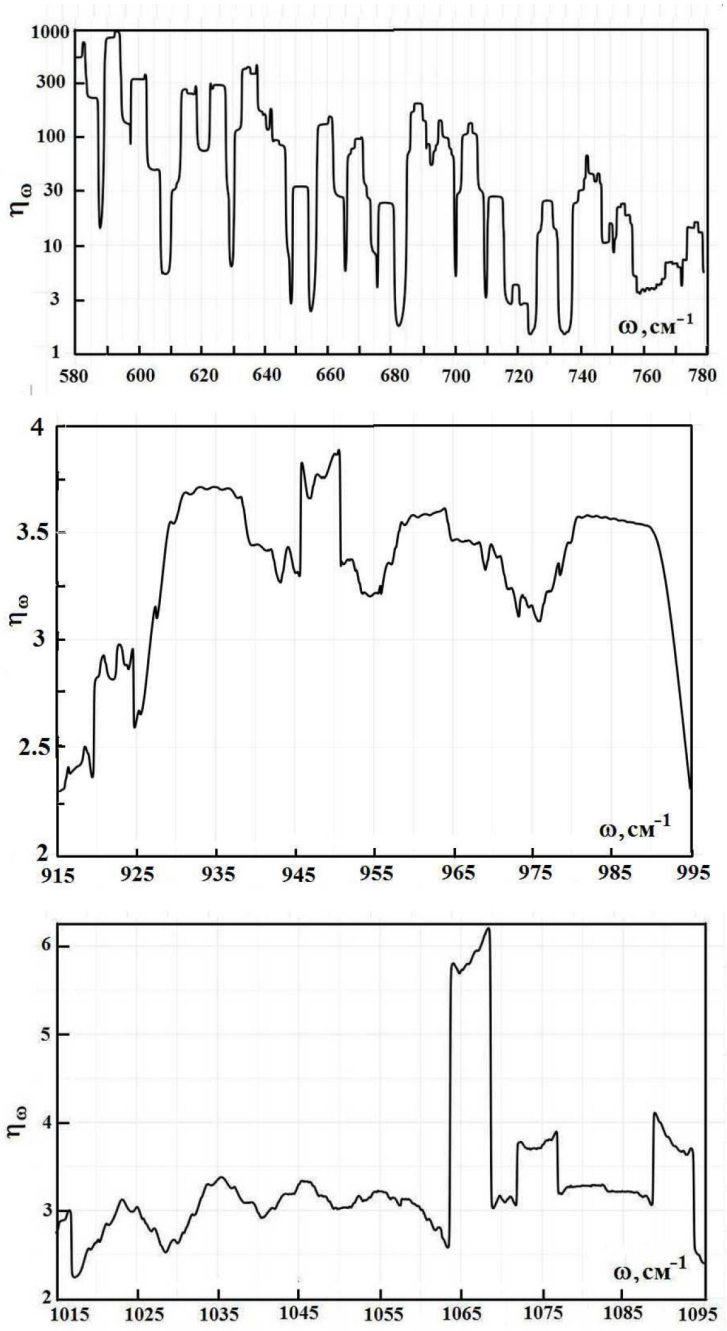

Figure 5: Ratio (3.2) averaged over the range of 10cm^{-1} for the absorption bands which corresponds to emission of atmospheric carbon dioxide [35].

determined by emissions of carbon dioxide in the atmosphere as a result of burning of fossil fuels.

4. CARBON EQUILIBRIUM AT THE EARTH

The processes involving carbon play an important role not only in the energy balance of the Earth, but also in life processes, and therefore we will consider the participation of carbon in these processes separately. The carbon equilibrium between the atmosphere and the Earth's surface due to these processes is established over a period of about 4 years – the lifetime of carbon dioxide molecules in the atmosphere. When assimilated by the Earth's surface as a result of photosynthesis, carbon passes into biomass. The equilibrium of carbon between the surface and the bowels of the Earth is carried out for times of the order of a thousand years. Therefore, the scale of the considered times can be neglected by the departure of carbon inside the Earth. The carbon balance for the atmosphere is shifting as a result of human energy activity, and during the industrial era (about 300 years), the increase in carbon circulation between the atmosphere and the Earth's surface increased by about one and a half times.

The equilibrium of carbon between the Earth's surface and the atmosphere is carried out as a result of the process of photosynthesis, which converts carbon dioxide into biomass, i.e. into biological material of plants. The inverse process is breathing and rotting of plants. By analogy with other planets, one can assume that at the first stage of the Earth's evolution, its atmosphere contained carbon dioxide. As a result of the photosynthesis process, carbon dioxide of the atmosphere was further converted into oxygen, and the resulting carbon went into the bowels of the Earth. This process determines the amount $5.4 \cdot 10^4$ GtC of carbon in the bowels of the Earth.

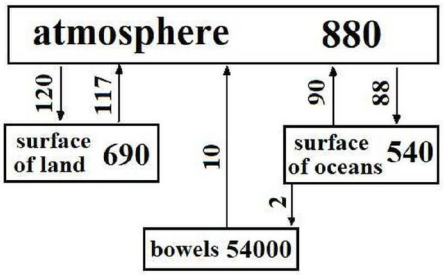

Figure 6: Carbon balance between the atmosphere and biosphere of land and oceans. Carbon fluxes are expressed in units GtC/yr (gigatons of carbon per year) and indicated near arrows, while the carbon amount is given inside rectangles and is expressed in GtC.

The carbon balance between the Earth's surface and atmosphere is represented in Fig.6 which is constructed on the basis of data [36, 37, 38, 39, 40, 41, 42, 43] for the carbon balance with corresponding corrections. As a result of processes involving carbon, its total mass, including the biomass of the Earth's surface and atmospheric carbon dioxide, has increased by one and a half times. This increases the rate of biomass formation, including crop yields by one and a half times. Note that the used unit for the carbon mass is $1\text{GtC} = 1 \cdot 10^{15}\text{g}$. The concentration of carbon dioxide in the Earth's atmosphere is measured in ppm (part per million). The connection between these units is 1ppm = 2.124GtC.

Carbon is of importance for mankind, since burning of fuels is responsible for the production of 80% of the world energy, and agricultural food production is also important. But the capacity of the land for food production is limited. In particular, at the end of the 18th century, Malthus conducted a serious analysis based on statistical data for a number of European countries, showing that the population grows exponentially over time, while the harvested crop grows linearly. Therefore, at a certain stage of human development, food will not be enough to feed the population.

This problem was acute until the sixties of the 20th century, when the green revolution took place in food production and harvests increased dramatically. In particular, over the past 60 years, the world's population has grown by about 2.5 times, while the total harvest has grown by 3.6 times, and an increase in the concentration of CO_2 in the atmosphere has made a certain contribution to this growth. The upper limit for the population that can be provided with simple photosynthetic products is approximately 300 billion people compared to the 8 billion currently living and 3 billion in 1960. We assume in this estimate that the daily food intake according to the UN data is 3000 kcal [44] and are based on the current efficiency of photosynthesis. One can add to this that the increase in the concentration

of carbon dioxide in the atmosphere does not affect human health, since its concentration in the exhaled air is much greater than in the atmosphere.

5. SOME ASPECTS OF ENERGETICS DEVELOPMENT

The rejection of the first two myths formulated in Introduction changes our attitude to contemporary energy production. The character of energy production has changed several times during the industrial period of our civilization. Currently, about 80% of the produced energy is associated with the burning of coal, oil and gas, including their derivatives. The contribution of this type of energy is reduced over time due to the development of so-called renewable energy types, solar and wind ones. Their contribution to the production of total energy is 5% in 2022 [45]. The production of energy from wind increased from 2012 to 2021 at a rate of 12% per year, and the growth of solar energy in this period was 16% per year [46].

Disadvantages and problems exist for each type of energy production. In particular, for wind energy, this is the disposal of large blades of wind turbines, the material of which includes a compound of polymers and metals. Risks of the solar energetics are associated with the use of arsenic and other chemical compounds that pose a danger to humans, but provide high efficiency of solar energy conversion. With the development of energetics, these disadvantages and risks will be reduced. But the fundamental feature of renewable energetics, which is determined by dependence on environmental conditions, remains and the inability to regulate the power generated.

Apparently, nuclear power is the cleanest type, but only because it is under the most stringent requirements, the fulfillment of which increases the energy cost. The use of a certain type of energetics depends on specific conditions. For example, areas of south and Southeast Asia with a stable sunny weather are optimal for solar energetics. In addition, in order to regulate the power of the generated energy, energy accumulators are needed. They collect and store the excess of the generated energy, and return it to consumers when needed. For this purpose, the mass media offer hydrogen energy, when the excess of the generated energy is spent on hydrogen production, and then this energy can be returned, to a large extent, by burning of hydrogen.

The presented concept is considered here as the third myth. This method of energy storage has been called hydrogen energetics, although since the mid-19th century this term has referred to a fuel cell that quickly converts the energy of the chemical reaction of hydrogen and oxygen into electrical energy. In fact, the concept of hydrogen energy suggests replacing the natural gas currently used with hydrogen. But unlike methane, hydrogen can only be transported through special tubes due to hydrogen chemical activity. Accordingly, hydrogen is not suitable for mass consumption, as well as for storing it in large volumes. This is proved, in particular, by the experience of the development of hydrogen-powered airships, which dates back to the thirties of the 20th century. Usually, after several years of work, they exploded.

An alternative to the hydrogen energetics for energy storage is pumping stations, which have been considered since 1903. In the USA and China there are separate pumping station facilities with a capacity of 3 GW, and in China a complex of pumping stations with a capacity of 30 GW is being created. For comparison, the total capacity of the Volga-Kama cascade hydroelectric power plant, which serves half of the population of Russia, is 30 GW.

As for the carbon energetics, if coal reserves last for a thousand years, whereas oil and natural gas reserves are gradually exhausted and their production is gradually moving to the oceans and hard-to-reach areas. In such a situation, the issue of the production of synthetic liquid and gaseous fuels is on the agenda. In this context, we recall that Germany had such an experience during the war in 1944-1945. Then Germany was cut off from the areas of oil production in Romania and was forced to produce liquid fuel from coal.

A partial transition to synthetic fuel obtained from coal practically occurs at coal thermal power plants using dispersed coal in superheated water vapor [48].The transition to synthetic fuel, which is made from coal and replaces natural gas, is practically taking place at coalfired thermal power plants, in which coal is used in the form of powder in a water vapor. Supercritical temperature and pressure are created in the steam boiler, reaching 600oC and 320 atm, respectively. The efficiency of these power plants exceeds 40%. Thus, there is a gradual transition to a new technology of energy production, in which natural gas is replaced by pulverized coal.

The third myth formulated in the Introduction, propagated by the mass media, is associated with the refuse from carbon energetics, which corresponds to the replacement of fossil fuels as an energy source with hydrogen. The experience of using hydrogen in airships and rockets indicates a high risk of explosion when using hydrogen in large quantities. This excludes the mass use of hydrogen, especially as fuel for the population, which proves the inconsistency of the third myth.

6. CONCLUSIONS

Summing up the results of the analysis represented, we conclude that all the statements propagandized by the mass media of many countries in a categorical form and formulated in the introduction in the form of myths are untenable. Indeed, the increase in the concentration of carbon dioxide in the atmosphere as a result of the burning of fossil fuels is not the main factor in the increase in global temperature observed in recent decades, However, this process does not affect human health, but leads to a noticeable increase in crop yields. Therefore, false propaganda carried out by the mass media in the interests of the owner harms the population of the planet. However, since this action of the mass media is beyond the competence of the author, I leave it to the political and judicial authorities, and further, as in the article itself, I will focus only on the physical aspects of the problem.

First of all, we note that the warming of the planet is not the main threat to humanity in the near future, as the media are trying to convince us. Firstly, the observed increase in global temperature over the past hundred and fifty years, amounting to $1^{o}C$, is significantly less than seasonal and daily temperature variations, as well as less than the difference in typical annual average values of global temperature. Therefore, this change may not be noticeable to a person. On the contrary, the observed pollution of water and atmospheric air is a more urgent task for humanity.

It should be added to this that the rise in global temperature, which is identified by the media with climate change, is not the most important manifestation of this. The changing rate of natural processes such as burning of forests, intense floods, droughts and earthquakes are now a more important manifestation of climate change for humanity. Therefore, more thorough measurements of the rate and intensity of these phenomena are needed, as currently carried out for global temperature, humidity of atmospheric air, and in the atmospheric concentration of carbon dioxide.

The analysis shows the imperfection of contemporary climate models. Indeed, in the above analysis we relied on the model of the standard atmosphere [47], the parameters of which are averaged both over the globe and over time. Therefore they depend only on the height above the Earth's surface. This model includes various measured parameters of the atmosphere, which allow us to consider the atmosphere as a whole. In the framework of climate models [27, 28], the Earth's surface is divided into a three-dimensional grid of cells. In particular, instead of the global temperature in the standard atmosphere model, climate models use the current surface temperatures for each cell. It would seem that climate models give a more complete and accurate description of the Earth's surface and the lower part of the atmosphere interacting with it.

It would seem that climate models give a more complete and accurate description of the Earth's surface and the lower part of the atmosphere interacted with it. Indeed, climate models provide a more detailed description of the problems under consideration. It follows from the accumulated experience that the successful use of climate models requires careful attention to rates of processes involving each cell.Currently, climate models are not reliable.

The problems under consideration affect the interests of the majority of the world's population and relate both to the global energy sector and to global processes on the Earth's surface and in the atmosphere. Unfortunately, the mass media spread a distorted view of the real state of these problems, which in this article is formulated in the form of myths. The refutation of these myths, the modern understanding of global energy problems based on the results of long-term scientific programs, as well as the identification of the most important areas of research are the subject of the analysis presented above.

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