INTRODUCTION

It is generally accepted that the cause of global warming – increasing the concentration of greenhouse gases in the atmosphere due to emissions associated with industrial activity [1]. The strongest impact on the environment is carbon dioxide emissions from the burning of fossil fuels [2]. The main contribution to the emission of CO₂ makes carbon dioxide, which is released during the combustion of solid and liquid fuels [3]. Currently, about 9 billion tons of carbon is released during the year 1. Emission into the atmosphere in 1850 was 4 million tons of carbon. In the second half of the twentieth century, the rate of carbon emissions has increased significantly: from 1,630 million tons in 1950 to 9,170 million tons in 2010. The concentration of carbon dioxide in the atmosphere has increased, respectively, from 311 ppm in 1950 to 390 ppm in 2010. It is estimated Stern (2006), a dramatic change in the environment will occur if the concentration of carbon dioxide in the atmosphere exceed 450 ppm [4]. In this case, the global temperature will increase by more than 2°C compared with an average temperature for the period from 1951 to 1980. Since the concentration of CO₂ in 2010 had reached a value of 390 ppm, and increases by 2-3 ppm per year, the critical concentration will be exceeded in 20-30 years from now.

Obviously, the increase in carbon dioxide concentration in the atmosphere is an important factor when considering changes of the Earth's climate.

CHANGING THE ZONAL TEMPERATURE

Currently, there is evidence of a change in global temperature in the world from 1880 to the present [5]. An important indicator of climate change is the zonal temperature, which is the average temperature within the zone. Often not the temperature is compared, and their deviation from the mean. In what follows, as mean value is taken the time-averaged temperature for the interval 1951 - 1980 years. An essential feature of the temperature deviation is the presence of two components: an oscillating and trend (see Figures 1 and 2).

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1 Here annual emission is measured in millions of tons of carbon. To convert to the amount of emissions of carbon dioxide corresponding values should be multiplied by 3.667
Line with a period of about 21 years dominates in oscillatory component (see Figure 3).

It points to the possible connection between short-term changes in the Earth's temperature and the 22-year cycle of solar activity. In this case, there should be a significant correlation between the oscillations in both hemispheres. Indeed, short-term changes in temperature in the northern and southern hemispheres are correlated (see Figure 4). The correlation coefficient $r = 0.57$. For number of degrees of freedom $n = 132$ the correlation is statistical significant (probability of the null hypothesis $p < 0.0005$). In addition to short-term oscillations in temperature there is a long-term temperature change (trend). The existence of a trend is usually attributed to the greenhouse effect of carbon dioxide. Comparison of temperature trend curve and changes in $CO_2$ concentration indicates a discrepancy between them at some time intervals, for example, 1880-1910, 1910-1940 and 1940-1960 (see Figure 5). Apparently, there are other factors besides the greenhouse effect influencing long-term temperature change on the Earth.
Emissions of carbon dioxide occur mainly in the northern hemisphere. The mixing time in the hemisphere is about 3 months, and between the hemispheres - about 1 year. Therefore, differences in temperature changes in the hemispheres can not be due to the uneven distribution of CO₂. Next, we will analyze only the smoothed component of temperature variations (trends). After 1970, the temperature of both the northern and southern hemisphere, increases monotonically. Now it is important the examination of the behavior of trends in the range of 1970-2013 (see Figure 7). Attention is drawn to the behavior of temperature deviations to the polar zone. For interval of 1970-2013 the temperature rise exceeded the average for geosphere by 1° C.

REGRESSION ANALYSIS

In this section, we discuss the correlation between the temperature variations, the concentration of carbon dioxide in the atmosphere, as well as with the position of the magnetic north pole. A comparison will be made between the zonal temperature, which we denote by Y, CO₂ concentration, and some other parameters, which we denote by \( X_1 \) and \( X_2 \).

\[
Y = aX_1 + bX_2. \tag{1}
\]

We will look for options \( a \) and \( b \), such that they will give the maximum correlation between the right and left side of (1). This approach is called multiple regressions. It allows you to determine which parameters of the \( (X_1, X_2) \) have significant effect on the change in the right-hand side of (1). Since the changes in CO₂ concentration are not fully explained the change in the zonal temperature anomalies, we will extend the set of parameters \( \{X\} \), adding the latitude of the north magnetic pole (NMP) as the second parameter. Basis for the inclusion of latitude north magnetic pole into the parameter set \( \{X\} \) is similarity between the two curves:

1. changes in the concentration of CO₂ and
2. changes in latitude of the magnetic pole in the 20th century (see Figure 8).

So we have carried out the regression analysis of data. We examined the dependence of the zonal temperature deviations on two parameters: the concentration of carbon dioxide and latitude of the north magnetic pole for the period 1970-2010 years. The results are shown in Table 1.

<table>
<thead>
<tr>
<th>Zone of the northern hemisphere</th>
<th>( \partial T / \partial C )</th>
<th>( \partial T / \partial L )</th>
<th>( R )</th>
</tr>
</thead>
<tbody>
<tr>
<td>90° N –64° N</td>
<td>0.671</td>
<td>0.726</td>
<td>0.99</td>
</tr>
<tr>
<td>90° N –24° N</td>
<td>0.757</td>
<td>0.189</td>
<td>0.97</td>
</tr>
<tr>
<td>90° N –0°</td>
<td>0.827</td>
<td>0.0</td>
<td>0.98</td>
</tr>
</tbody>
</table>

In Table 1, the following notation is used.

1. \( \partial T / \partial C \) – partial correlation coefficient of zonal temperature by the concentration of CO₂
2. \( \partial T / \partial L \) – too, for the zonal temperature and latitude of NMP
3. \( R \) – coefficient of determination. The value indicating what proportion of variation of the independent variable (temperature) is explained by the parameters of right-hand side (CO₂ and latitude)

As follows from the Table 1 (see Column 3), the effect of the pole position on the zonal temperature in the northern hemisphere decreases with displacement of the outer boundaries of the zone to the equator (see Column 1). This suggests that the physical factor which determining the impact on the zonal temperature, localized in the polar region. One of these factors, that determine the transport processes in the atmosphere of the polar zones, is Arctic oscillation.

ARCTIC OSCILLATION AND THE POSITION OF THE NORTH MAGNETIC POLE

Arctic oscillation or changes in the northern circulation is an index of change of pressure at sea level to the north of 20° N (see Figure 9).
It characterizes the pressure anomalies in the Arctic relative to the pressure in the lower latitudes of the northern hemisphere with the center of the measurement at latitudes 37-45° N. Arctic oscillation is one of the main factors that determine the weather of the northern hemisphere during the winter period. Change in the index over long time intervals has no strict periodicity. There are two phases of Arctic oscillations. Negative phase is characterized by increased pressure in the stratosphere of the polar zone and a strong jet stream at the edge of high and medium pressure. Positive phase is characterized by a lower pressure in the stratosphere of the polar zone and less intense jet stream.

Figure 10 shows that on the considered time interval the years with predominantly positive phase appear after 1970. Approximately in the same time period the temperature in the northern hemisphere begins to increase monotonically, and particularly in the polar zone 90° N – 64° N (see Figures 7 and 11). In the 70s begins a period of rapid increase in temperature in the northern hemisphere, which ends in 2010. During this time, the rate of increase in temperature in the northern hemisphere exceeded the rate changes in the southern hemisphere.

To explain the phenomenon of the rapid increase in temperature in the northern hemisphere, we compare the latitude the north magnetic pole and AO indices (see Figure 13).

It is seen (see. Figure 13) that in the time intervals in which the latitude of pole increases rapidly, AO goes to the positive phase, which is characterized reduced pressure and less cold air in the polar zone. If we compare the changes of temperatures in several areas of the Northern Hemisphere (see Figure 12), it becomes clear that the excessive warming in the polar (90° N – 65° N) and in the middle zones of the Northern Hemisphere (65° N – 44° N) was accompanied at the same time with less warming in the subtropical (44° N – 24° N) and tropical (24° N – 0°) zone. Thus, there is following conception, explaining the effect of a stronger warming of the polar zone at the end of the twentieth century. Due to the rapid movement of the magnetic north pole the arctic oscillation goes in a positive phase. In the Arctic region of the northern hemisphere was formed area of low pressure, which contributed to the transfer of warm air masses from the mid-latitudes in the northern areas. As a result, in the northern hemisphere has been a redistribution of heat.
SUMMARY AND CONCLUSIONS

The direct indicator of the observed global warming is the temperature. The properties of temperature changes were considered at different time scales. It is shown that short-term fluctuations have a time scale of ~21 years and occur simultaneously in the northern and southern hemispheres. It was suggested a connection between these fluctuations and solar activity. Long-term changes in temperature are usually associated with an increase in the concentration of carbon dioxide in the atmosphere. The performed analysis has shown that the increase in temperature not uniquely is associated with increased CO₂ concentration. Currently, works have appeared in which examines the relationship of climate change with the position of the magnetic poles (eg, [9]). We performed a regression analysis of data on temperature, carbon dioxide concentration and latitude of the north magnetic pole for the 1970-2010 years. It is shown that the dependence of zonal temperature on latitude pole increases significantly for the subpolar zone (90° N - 64° N) compared with zones that include the middle and subtropical latitude (90° N → 24° N, 90° N → 0°). This allows us to conclude that the processes which additionally affect the change in temperature, localized in the polar zone. We have considered connection of the Arctic oscillation (AO) with the change in the latitude of the north magnetic pole (NMP). It is shown that the phase change AO occurs in the periods of increasing velocity of the NMP.

REFERENCES

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