



## *The invisible dangers of the climate change*

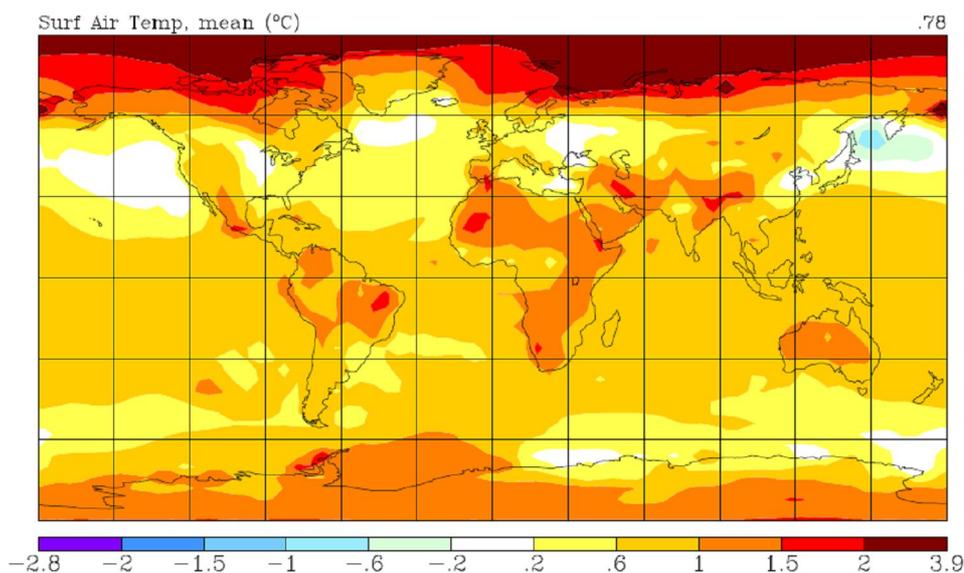
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*Moscow, 2009*

Climate change is a fact; especially we can take for granted one of its manifestations – the global warming (see Fig. 1). The data of meteorological observations shows that over the past 100 years the average surface temperature has increased by 0.74° C and the warming rate is accelerating. There is no consensus on whether the observed increase of surface temperature is a one time anomaly or one of the stages in the next Ice Age. A growing number of scholars are supporting the hypothesis that the observed climate change is man-made and is a result of human economic activity. The improved models of the global patterns of atmospheric and oceanic circulations allowed scientists to formulate the main threats to human life resulting from the growth in the average temperature on the planet.

*Figure 1. Changes in temperature from 1880 to 2000.*



Source: <http://data.giss.nasa.gov/cgi-bin/cdrar/effij.py>

## **The fundamentals of the global of warming**

Earth's climate is changing as a result of natural processes and in response to external influences, including man-made influences. The climate change is recurring (confirmed by studies of ice cores in Antarctica). Humanity now lives in a period between the ice ages<sup>1</sup>.

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<sup>1</sup> Ice Age - a relatively long phase of the geological history of Earth, during which the climate cooling repeatedly alternated periods of very cold climate (glacial) and the periods with warmer climates, where a large part of continental glaciers melted (interglacial).

The main causes of the global climate change include:

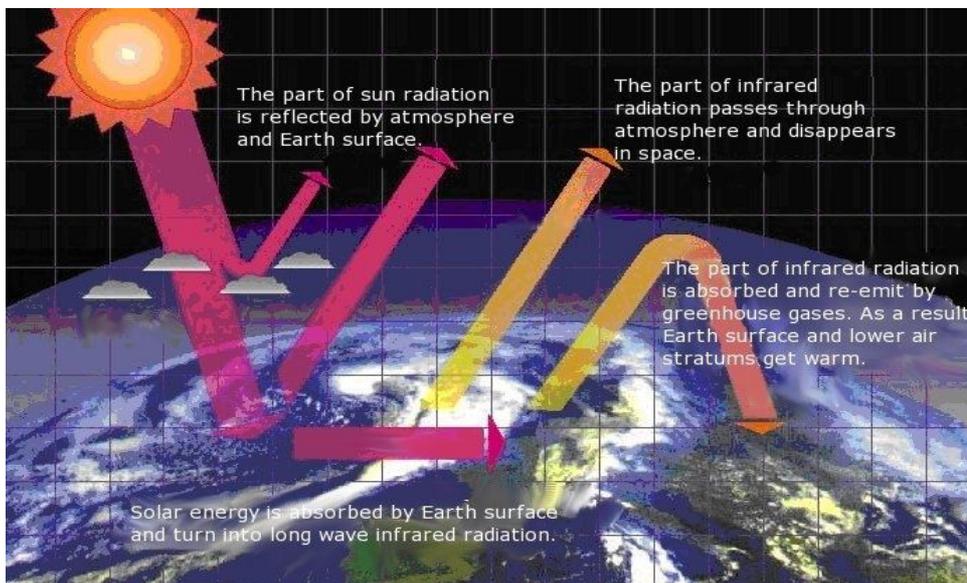
- changes in Earth's orbit (Milankovitch cycles<sup>2</sup>);
- variation of solar activity;
- volcanic emissions;
- the greenhouse effect.

In the recent years one of the most popular contemporary theories of climate change is the enhanced greenhouse effect resulting from human activity. There are other hypotheses, but none was so broadly accepted by the public. Moreover, based on the theory of human influence on Earth's climate many countries have approved measures aimed at preventing negative effects of human activities, most notably the Kyoto Protocols.

### **The role of the greenhouse effect**

The greenhouse effect (see Fig. 2) was first described by the English physicist J. Tyndall<sup>3</sup> in 1860. He suggested an increase in the surface temperature due to the atmospheric reflection of the infrared (IR) radiation emanating from the Sun.

*Figure 2. The Greenhouse Effect*



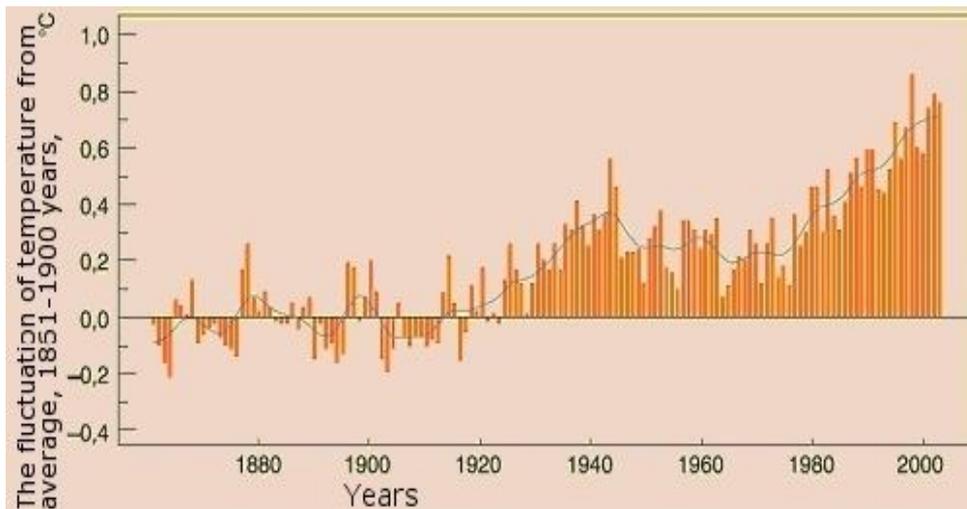
*Source: Intergovernmental Panel on Climate Change*

<sup>2</sup> Milankovitch cycles describe recurrent deviations in insolation in the hemispheres by average 5-10% during long periods of time.

<sup>3</sup> "The waves of heat speed from our earth through our atmosphere towards space. These waves dash in their passage against the atoms of oxygen and nitrogen, and against molecules of aqueous vapour. Thinly scattered as these latter are, we might naturally think of them meanly as barriers to the waves of heat."

It is important to note that the link between the concentration of greenhouse gases in the atmosphere and the increase in the average temperature is a complex system of interconnected processes. Nevertheless, since the beginning of the industrial development (circa middle of the 18th century) the concentration of greenhouse gases began to increase exponentially<sup>4</sup>, hence the hypotheses of the man-made climate change (see Fig. 3).

*Figure 3. The average air temperature on the surface layer of the atmosphere.*



*Source: Stern review on the economics of climate change*

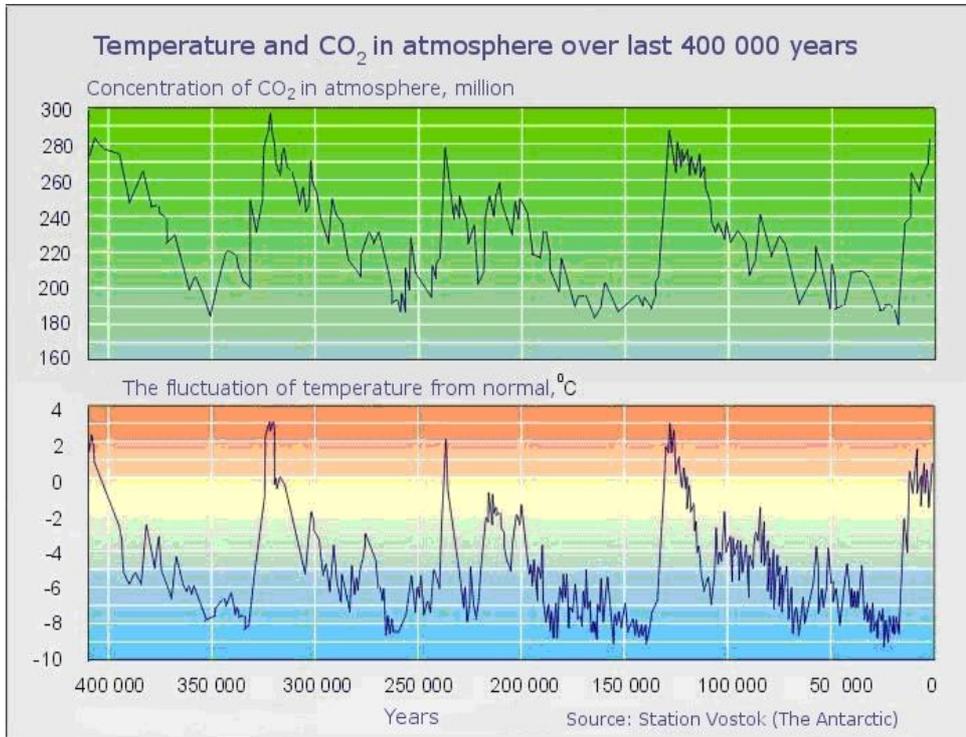
The popularity of anthropogenic hypothesis can be attributed to the following factors. Firstly, it is most consistent with other well-known hypotheses and secondly, it can be incorporated into the theory of "self regulating" climate change. Indeed the industrial activity is a source of carbon dioxide; it is the trigger of the greenhouse effect and the resulting increase in the concentration of greenhouse gases.

Meanwhile, some scientists have a different view<sup>5</sup>, arguing that the human contribution to the process of climate change is negligible. Indeed, the processes of warming/cooling were observed during most of Earth's history (see Fig. 4).

<sup>4</sup> M.I. Budyko "The climate in the past and the future". Hydromet.1980

<sup>5</sup> N. Oreskes "The Scientific Consensus on Climate Change" (2004) Science 3, Vol. 306, no. 5702, p. 1686, December

Figure 4. The dynamics of the concentration of CO<sub>2</sub> and the average temperature of the Earth's surface.



Source: <http://enrin.grida.no/htmls/tadjik/vitalgraphics/rus/html/c4.htm>

Despite different views on the causes of the climate change calculations suggest that while maintaining modern growth over thirty years we should expect the increase in the concentration of greenhouse gases in the atmosphere equivalent to the doubling of CO<sub>2</sub><sup>6</sup> concentration. In several decades this would lead to a global climate disaster. It is therefore not surprising that over the last several years the problem of climate change is actively debated in scientific circles and at the intergovernmental level with the active assistance of the UN.

### **Human influence on climate**

Emissions of greenhouse gases in the atmosphere are only one of several factors influencing the climate. At the same time natural processes work in the opposite direction. For example atmospheric carbon is actively absorbed by green plants during photosynthesis; it also dissolves in the oceanic water turning into chemically inactive compounds (calcification into marine organisms)<sup>7</sup>. There are other ways of linking

<sup>6</sup> World Economic Outlook, October 2007

<sup>7</sup> K. Keller, K. Tan, et al. "Preserving the ocean circulation: implication for climate policy" (2000) Climatic Change 47: 14-43

carbon dioxide and other greenhouse gases. But there is not a clear quantitative model connecting CO<sub>2</sub> and greenhouse gases. Given that we don't have a full understanding of the mechanisms of the carbon cycle (and other gases) there is no guarantee that reducing CO<sub>2</sub> emissions will stop the observed increase in the concentration of the greenhouse gases.

Climate change (in one direction or another) occurred in the past when human activities could not affect them<sup>8</sup>. No one denies the studies that the Earth's warming was always accompanied by an increase of the CO<sub>2</sub> in the atmosphere. However in the opinion of the most prominent Russian geophysicist O. Sorochtin<sup>9</sup> justifying the connection between the concentrations of greenhouse gases and global warming confuses the cause and the effect. We know that the solubility of carbon dioxide (as the majority of gases) in water decreases with increasing temperature. Therefore any warming of the oceans forces the release of so much CO<sub>2</sub> that all man-made emissions fall within the margin of error.

Moreover global warming will be accompanied by melting of the permafrost, releasing into the atmosphere of huge quantities of methane (the second most important greenhouse gas). O. Sorochtin showed that "the bigger is absorption of heat radiation in the troposphere; the lower becomes its average surface temperature"<sup>10</sup>. Member of RAS A. Kapitsa is in agreement, he argues that "even the great man-emissions of carbon dioxide in the earth's atmosphere do not noticeably change the temperature of Earth and do not create a greenhouse effect. On the contrary, we should expect cooling in the small percentage of degrees".

According to this view measures aimed at reducing emissions, in particular the adoption of the Kyoto Protocols will not have results. Similar views expressed by Western scholars. For example, former President of the U.S. National Academy of Sciences F. Zeitz invited the scientific community to sign a special petition calling on the Government of the United States and other countries not to sign the Kyoto Protocol on limiting greenhouse gas emissions<sup>11</sup>. Today this position is not supported by most politicians or scientists.

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<sup>8</sup> In the past, the temperature fluctuations were much greater, however, was not as fast.

<sup>9</sup> O.G. Sorochtin "The evolution and prognosis of changes in global climate of the Earth", Space Research Institute, 2006

<sup>10</sup> O.G. Sorochtin, S.A.Ushakov "The nature of the greenhouse effect" [http://www.scgis.ru/russian/cp1251/dgggms/1-98/par\\_eff.htm](http://www.scgis.ru/russian/cp1251/dgggms/1-98/par_eff.htm)

<sup>11</sup> <http://www.petitionproject.org/>

## Future projections

Anthropogenic annual emissions of about 7 Gt/year, not a high rate compared to other processes<sup>12</sup>. However, the lack of absorption of additional CO<sub>2</sub> emissions beyond carbon exchange may lead to higher concentrations, unwinding very slowly, even in the complete cessation of anthropogenic emissions.

According to the forecasts of the Intergovernmental Panel on Climate Change (IPCC), the most authoritative international organization in the study of climate, in the next twenty years temperatures will rise on average by 0.2° C per decade, and by the end of 21st century the Earth's temperature could increase by 1.8° C to 4.6° C (depending on various scenarios for the world economy and society<sup>13</sup>).

IPCC projections for future growth of carbon dioxide in the atmosphere significantly depend on the choice of development strategy for the industry, energy, transportation, etc. Under the scenario, by the end of this century we can expect three fold increase in the concentration of carbon dioxide compared to the current level.

However, let's not consider the causes of global warming but the necessary decisions need to counteract it. It is appropriate here to mention one of the key principles of the UNFCCC which states that "lack of full scientific certainty should not be used as a reason for postponing measures to prevent or minimize the causes of climate change or mitigate its adverse effects."<sup>14</sup>

## The high degree of uncertainty

Uncertainty can be defined as poor knowledge of the likelihood that an event or state-of-nature will occur. Uncertainty can constitute anything from 'confidence just short of certainty' to 'speculation'. Furthermore, uncertainty, particularly in relation to the impacts of climate change, can derive not just from lack of knowledge, but also from disagreement about what is known or even knowable.

Thus, sources of uncertainty may include:

- data problems, such as missing data, or data errors;

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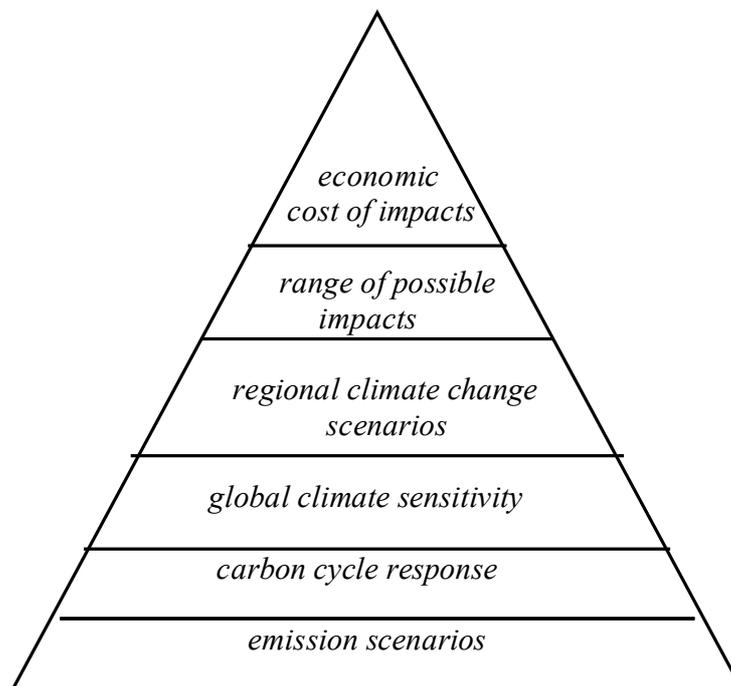
<sup>12</sup> The atmosphere contains about  $7.5 \times 10^2$  Gt of carbon in the hydrosphere  $4 \times 10^4$  Gt (data for CO<sub>2</sub> are given in terms of carbon). The exchange between the atmosphere from hydrocarbon land is about 60 Gt/year, while the ocean about 90Gt/year.

<sup>13</sup> IPCC experiments were conducted with 23 complex physical and mathematical models of the atmosphere and ocean, represented by 16 leading research groups from 11 countries. The basis of the draft estimates of climate 20<sup>th</sup> century at given concentrations of greenhouse gases and aerosols, as well as three scenarios in calculating the climate 21<sup>st</sup> century ("hard", "mild" and "soft")

<sup>14</sup> <http://unfccc.int/resource/docs/convkp/convru.pdf>

- problems with models (physical or economic) such as structure, parameter values, predictability and approximation techniques and inappropriate underlying assumptions; and
- other sources of uncertainty including ambiguous concepts and terminology, inappropriate spatial or temporal units, and uncertainty due to projections of human behavior<sup>15</sup> (see Fig. 5).

*Figure 5. Range of Uncertainty Typical in Climate Impact Assessments.*



Thereby there is considerable uncertainty in the quantitative estimates of the climate change future impact on ecosystems, economic activities and social processes in different countries and regions<sup>16</sup>. Both positive and negative effects are possible, depending on the level of development of the region and its climate. Unfortunately the accuracy of current projections is mediocre at best. None of the models can fully predict the climate.

Hence the need for simplification and simplification leads to uncertainty. The uncertainty inherent in climate scenarios and the development of regional scenarios is still at early stages. Poor reliability of weather forecasts is due to the complexity of the

<sup>15</sup> R. Moss, S. Schneider, "Uncertainties in the IPCC TAR: Recommendations to Lead Authors for More Consistent Assessment and Reporting" (2000), IPCC.

<sup>16</sup> V.M. Katsov, V.P. Meleshko, S.S.Chicherin "Climate Change and the national security of the Russian Federation", Journal of Law and Security number - 1-2 (22-23), July 2007

description of the transfer of solar and thermal energy in the atmosphere and the simulation of feedbacks in the atmosphere, the land and the ocean.

In recent years the theoretical methods of study of the atmospheric radiation transfer have been improved<sup>17</sup>, reducing calculation error. In particular, the American pilot program for studies of atmospheric radiation (ARM)<sup>18</sup> is a unique experiment on measurements of the radiation in different climatic zones.

Large-scale studies of the World Climate Research Program and the International Geosphere – Biosphere Program promise a qualitative improvement of the climate forecasts. There is hope for a significant improvement in weather forecasts in the near future<sup>19</sup>.

### **The economic consequences of climate change**

Due to the significant uncertainty of climate projections range of estimates of the possible economic effects of global warming remains broad. Increase in global mean temperature of 2.5° C by the end of the century, compared with the levels of 1980-1999, will create an advantage for some regions and markets and at the same time will be costly for other regions and industries<sup>20</sup>. These forecasts correspond to the "baseline" scenario for the changes in temperature, in line with estimates for doubling levels of CO<sub>2</sub>. In addition there are some quantitative models of expected climate change and its influence on economy<sup>21</sup>.

#### *Agriculture*

The impact of warming on the agricultural productivity is ambiguous. Climate change could affect agriculture in many ways. In some climates crop yields could increase with a small increase in temperature and decrease with a large temperature changes. At the same time according to the projections in tropical and subtropical regions yields will decline.

According to researchers from the Massachusetts Institute of Technology increased rainfall associated with global warming will have a much stronger effect on the

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<sup>17</sup> B.A. Fomin, Y.V. Gershanov, Data bank on benchmark calculations of solar and long wave radiation fluxes in atmospheres for climate studies // IRS'96: Current Problems in Atmospheric Radiation. Hampton, 1997, pp.815-817.

<sup>18</sup> G.M. Stokes, S.E. Schwartz, The atmospheric Radiation Measurement (ARM) program: programmatic background and design of the cloud and radiation test bed. // Bul. Amer. Meteor. Soc. 1994. V.75, pp. 1201-1221. (Atmospheric Radiation Measurements)

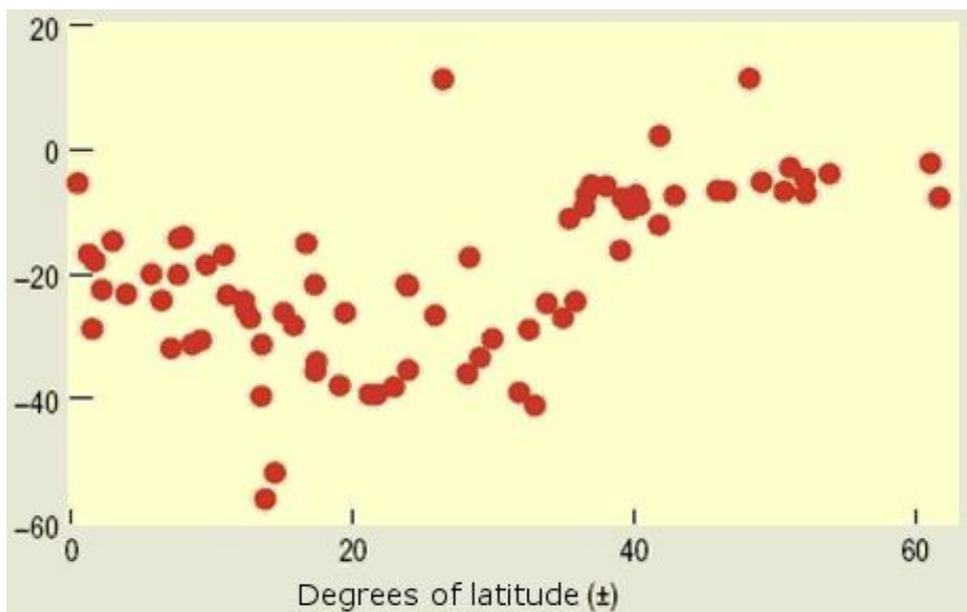
<sup>19</sup> B.A. Fomin, E.A.Zhitnitsky, Collection "General problems of post-industrial era / Moscow Public Science Foundation, the Institute of World Economy and International Relations, Russian Academy of Sciences. Moscow 1999

<sup>20</sup> If you raise the temperature of more than 2.5° C expected a dramatic effect (flooding of coastal areas, flooding because of torrential rains, frequent droughts, more powerful storms, unbearable periods of heat, political and social consequences due to the large migration population caused by the need to leave the uninhabitable areas).

<sup>21</sup> W. Nordhaus "An Optimal Transition Path for Controlling Greenhouse Gases" (1992) Science, V. 258

increasing level of groundwater than previously thought. A negative consequence of this will be a sharp increase in groundwater levels that would adversely affect agriculture, particularly in the Far East and South-East Asia, and a bigger risk of landslides. Numerical calculations showed that the closer the country is to the equator, the greater is the likelihood that its agriculture will suffer from the warming (see Fig. 6).

*Figure 6. Potential percentage change for the productivity in agriculture.*



*Source: Cline, William R., 2007, Global Warming and Agriculture: Impact Estimates by Country (Washington: Center for Global Development and Peterson Institute for International Economics)*

The most serious damage might be for the agricultural sector in Africa with the poorest population in the world. According to the IPCC, by 2080 the number of people facing the threat of hunger could rise by 600 million. More than double the number of people who now live in poverty in the sub-Saharan Africa.

IPCC notes that there is possible loss due to the global warming as a consequence of reduced moisture content in the soil, increasing the number of pests on vegetation, increased plant and animal diseases, as well as the effects of the heat stress. In addition, in some regions the increase in rainfall will lead to soil erosion, while other regions will see drought. Models predict that in a number of mid-latitude regions (e.g. U.S.) the number of dry years could rise from 5% currently to 50% by 2050.

According to a report by UN Secretary General P.G. Moon possible damage due to global warming may reduce the yield of major crops in some countries by 50% so that by 2020 the number of people suffering from hunger may increase by almost 50 million. By 2080 (agricultural) production in the developed countries could be reduced by 9%-21%.

There are possible positive effects for the economy, i.e. the longer season favorable for the growth of plants. In addition yields are expected to increase with the increase in the concentration of CO<sub>2</sub> due to the well-known catalytic action of carbon dioxide in the photosynthesis of plants. According to laboratory experiments, the doubling of CO<sub>2</sub> concentration can increase by a third yield of rice, soybeans and other crops.

#### *Water use and water supply*

One of the consequences of the climate change can be a shortage of drinking water. In dry regions (Central Asia, the Mediterranean, South Africa, Australia, etc.) the situation will worsen because of the reduction in the level of rainfall. It is anticipated that because of the droughts and other effects associated with climate change the annual economic losses due to water supply disruptions could reach \$50 billion<sup>22</sup>.

According to the UN over the past 100 years the rate of water consumption has increased two times faster than population. The waters are chronically lacking in the Middle East, North Africa and South Asia. UN predicts that by 2025 1.8 billion people will live in countries or regions where water is extremely scarce and two-thirds of the world may be confronted with the problem of inadequate provisions of the water resources.

#### *The impact on health and quality of life*

Climate change, scientists predicted, would lead to increased risks to human health, especially for the poorer segments of population. Thus, the decline of food production would inevitably lead to malnutrition and hunger. Abnormally high temperatures can lead to cardiovascular, respiratory and other illnesses.<sup>23</sup>

Higher temperatures could lead to changes in geographical distribution of various species of animals and insects that are carriers of disease while people living in these territories would not be immune to new diseases. According to D. Stone, P. Scott, et

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<sup>22</sup> "Climate change and its implications in the short and long term under different scenarios, 2007, IPCC

<sup>23</sup> According to the World Health Organization (WHO), the additional deaths in European countries from the heat wave in August 2003 in the UK amounted to 2045 people, in France - 14802, Italy - 3134 in Portugal - 2099.

al.<sup>24</sup> it is very likely (confidence level >90%) that human influence has at least doubled the risk of a 2003 heatwave.

On the one hand, global warming is clearly reduces costs for heating homes, but the increases the cost of air conditioning. In total the estimate of the economic loss for the world is approximately \$20 billion a year.

There are many factors resulting in a positive or negative impact on health from the climate change. Some of them may be direct, such as deaths due to heat, while others indirect, such as factors associated with changes in ecosystems. Very rough estimates show that global mean temperature increase by 25°C will lead to an additional 215,000 deaths per year, mostly in the developing countries. Malaria will infect 200 million more people. All of this leading to an estimated economic loss of approximately \$50 billion.

Changes in climate could lead to further migration of people because of the deteriorating living conditions in some areas and improvements to others. Estimates show that the migration of some 1.5% of the population of the Earth, or about 100 million people, could result in annual economic losses of several hundred million dollars.

#### *Landscape changes*

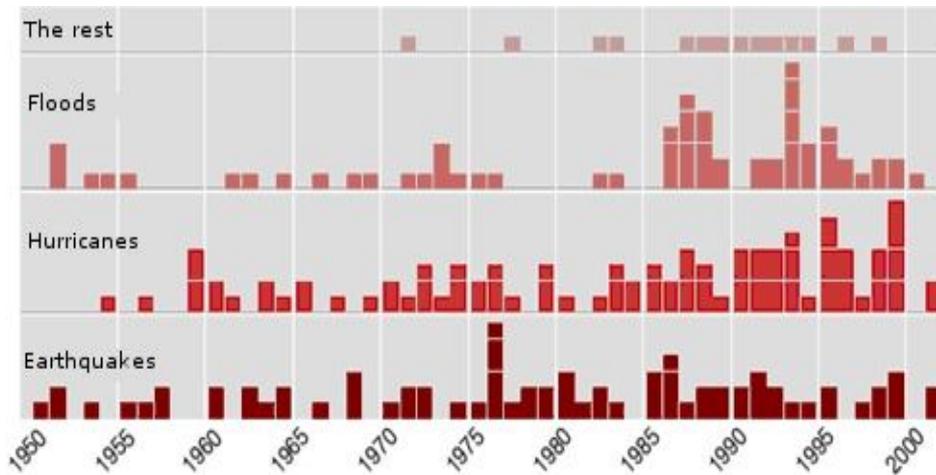
According to the forecasts of the IPCC the increase of sea levels by about 0.5 meters is expected by 2100, most seriously affecting the coastal zones and small islands. Three types of losses are expected from the rising sea level:

- additional capital cost for shore protection;
- loss of coastal land;
- costs of more frequent flooding (see Fig. 7).

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<sup>24</sup> D. Stone, S. Scott, M. Allen, M. Hawkins "Human contribution to the European heatwave of 2003" (2004), University of Oxford

Figure 7. The number of major natural disasters from 1950 to 2001.



Source: Munich Re 2001

According to the IPCC, the capital costs in this century only for the United States will be from \$73 billion to \$111 billion in case of rising sea level by a meter. It is estimated that in the case of sea-level rise by a meter there will be a 20% increase in the number of people living in the area of potential flooding and the U.S. might lose (without remedial work) 6,650 square miles of land. The sea level rise by 0.5 meters by the end of the century will require about \$1 billion annually for the world.

Expected slight increase in forest fires and the reduction of forestation due to droughts will be offset by a more intensive growth of forests due to the increased concentration of CO<sub>2</sub> in the atmosphere. In general the assessment of losses in the forestry sector due to climate change is uncertain, estimated at \$2 billion per year.

### Insurance

Since 1987, after a relatively quiet period of two decades, the insurance industry is beginning to bear the additional losses of about \$1 billion annually from weather related causes.

*Table 1. Most major hurricanes in recent years and the payment of insurance companies.*

| Hurricane        | Data           | Insurance value, \$ bln |
|------------------|----------------|-------------------------|
| <b>Hugo</b>      | September 1989 | 6,4                     |
| <b>Andrew</b>    | August 1992    | 21,5                    |
| <b>Ivan</b>      | September 2004 | 11                      |
| <b>Charley</b>   | August 2004    | 8                       |
| <b>Francis</b>   | August 2004    | 5                       |
| <b>Catherine</b> | September 2005 | 45                      |

Source: <http://www.archipelag.ru/agenda/geoklimat/economic-aspect/climate/>

#### *The impact on the ecosystem*

In this category both direct and indirect losses can be very high. For example, the reduction of mangrove forests can require additional investments for protecting coastal areas. The warming may also cause a loss of many animal and plant species due to the climate change and changes in relationship between different species, such as victim-predator systems, etc. According to some estimates it will require some \$30 billion a year.

According to observations from the 1900, northern hemisphere has lost about 7% of the permafrost. This is not only a problem for the local infrastructure but also for the vegetation. The loss increases the risk of the release of frozen methane from the soil, a very powerful greenhouse gas.

Increasing temperatures would lead to an increase in the concentration of ozone in the troposphere and other noxious gases. According to some estimates<sup>25</sup> restoration of the air quality to the same level would require approximately \$15 billion a year. Similar measures to restore water quality will require \$15 to \$67 billion a year.

The estimates of the economic damage from the climate change vary but various authors agree in their trend assessments. Estimates of the economic losses for the major regions of the world are presented in Tab. 2.

<sup>25</sup> B.A. Fomin, E.A.Zhitnitsky, Collection "General problems of post-industrial era / Moscow Public Science Foundation, the Institute of World Economy and International Relations, Russian Academy of Sciences. Moscow 1999

Table 2. Economic damage in billion dollars per year as a proportion of GDP due to global warming and in case of the doubling CO<sub>2</sub> (per major regions).

| Region         | Fankhauser <sup>26</sup> |       | Tol <sup>27</sup> |       |
|----------------|--------------------------|-------|-------------------|-------|
|                | \$ bln/year              | % GDP | \$ bln/year       | % GDP |
| Europe         | 63.6                     | 1.4   | -                 | -     |
| USA            | 61.0                     | 1.3   | -                 | -     |
| Former of USSR | 18.2                     | 0.7   | -7.9              | -0.3  |
| China          | 16.7                     | 4.7   | 18.0              | 5.2   |
| South Asia     | -                        | -     | 53.5              | 8.6   |
| Africa         | -                        | -     | 30.3              | 8.7   |
| Latin America  | -                        | -     | 31.0              | 4.3   |
| Middle East    | -                        | -     | 1.3               | 4.1   |
| <b>Total:</b>  | 269.6                    | 1.4   | 315.7             | 1.9   |

Source: <http://www.archipelag.ru/agenda/geoklimat/economic-aspect/climate/>

As shown in the table, predictions vary, especially for the former Soviet Union. In general for the world economy the expected economic losses amount to about 1% of the GDP. It should also be noted that the increase in global mean temperature of 5° C doubles the expected economic losses.

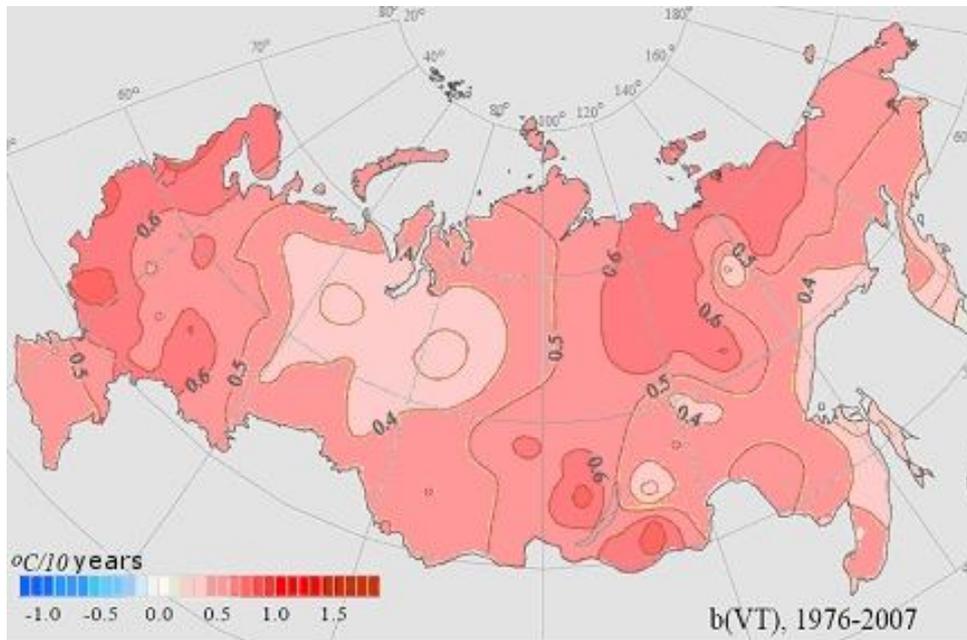
## Russia

According to the Russian meteorological observations, the average air temperature in Russia has grown over the past hundred years by 1°C (which is significantly higher than the world average). The increase of 0.4° C documented only in the last decade of 20<sup>th</sup> century (see Fig. 8).

<sup>26</sup> Fankhauser S. Valuing Climate Change: The Economics of the Greenhouse. London, 1995

<sup>27</sup> Tol R.S.J. The Damage Costs of Climate Change: Towards More Comprehensive Calculations // Environmental and Resource Economics. 1995. V.5, pp. 353-374

Figure 8. Anomalies of air temperature in Russia



Source: Report on Russian climate in 2007. Roshydromet - 2008

According to forecasts by Roshydromet, by the middle of the century Russia will warm up by 2° C, provided that the temperature growth is maintained. Although most scientists agree that the rate of warming will only increase.

It should be noted that due to a number of obvious geopolitical and other factors (hydrocarbon prices and food prices, the development of the nuclear energy, large and relatively unsettled territory, the existence of powerful and densely populated neighboring states, etc.) the study of the impact of climate change on the economy in Russia is very important. Because of the diversity of climatic zones, such research should be carried out for different regions of the country.<sup>28</sup>

Compared to global warming, regional climate change in Russia will be different. The impact on economic activity - both favorable and adverse will differ as well. “Livable” area can move to the north, reduced heating costs, reduced ice cover, new shipping routes along the Arctic coast and on major rivers, discovery of natural resources along the Arctic shelf, etc. At the same time more frequent droughts in some regions, flooding in others. Melting of the frozen permafrost soil can cause serious damage to

<sup>28</sup> B.A. Fomin, E.A.Zhitnitsky, Collection "General problems of post-industrial era / Moscow Public Science Foundation, the Institute of World Economy and International Relations, Russian Academy of Sciences. Moscow 1999

buildings and communications in the northern regions of Russia. Disturb the biological equilibrium change their species composition, may lead to serious migration problems.

## **Preventive measures**

### *Kyoto protocol*

All the current assessments of the economic damage due to possible climate change are uncertain even in the coming decades, but there is recognition that the danger is very serious, particularly because of the inability to counteract the natural processes effectively. In this regard, in 1995, many countries signed UNFCCC (United Nations Framework Convention on Climate Change) and article 2 reads: "The purpose of the convention ... to achieve stabilization of the concentration of the greenhouse gases in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system..."<sup>29</sup> Kyoto Protocols were drafted to achieve the objectives, obliging the member countries to limit emissions of greenhouse gases.

In 2003, Council of the Russian Academy of Sciences seminar was convened at the request of the President Vladimir Putin, consisting of 26 well known Russian scientists led by the Director of the Institute of Global Climate and Ecology of Roshydromet and Academician of Russian Academy of Sciences Y. Israel. The seminar issued an opinion highlighting negative implications for Russia in ratifying Kyoto Protocols agreement. Although the document entitled "Decision of the Council of the Russian Academy of Sciences seminar on the possible man-made climate change and the issue of the Kyoto Protocols" was sent to the President, the Prime Minister and Minister of Industry and Energy, still the document was ratified by Russia.

### *Geoengineering*

A few scientists are beginning to quietly raise the possibility of cooling the planet's fever directly through geoengineering. The principle behind it is straightforward – compensate for an intensified greenhouse effect by reducing the amount of solar radiation reaching the earth – but the techniques seem unrealized. Just a few: using orbital mirrors to bounce sunlight back into space, fertilizing the oceans with iron to amplify their ability to absorb carbon and even painting roofs white to increase solar reflection.

Nobel laureate P. Crutzen, who is well regarded for his work on ozone damage and nuclear winter, spearheaded a special August 2006 issue of Climatic

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<sup>29</sup> <http://unfccc.int/resource/docs/convkp/convru.pdf>

Change<sup>30</sup> with a controversial editorial about injecting sulfate aerosols into the stratosphere as a means to block sunlight and cool Earth. Another respected climate scientist, T. Wigley, followed up with a feasibility study in *Science* that advocated the same approach in combination with emission reduction<sup>31</sup>.

Some geoengineering schemes aim to remove carbon dioxide from the atmosphere, through natural or mechanical means. Ocean fertilization, where iron dust is dumped into the open ocean to trigger algal blooms; modification of crops to increase biotic carbon uptake; carbon capture and storage techniques such as those proposed to outfit coal plants; and planting forests are such examples. Other schemes involve blocking or reflecting incoming solar radiation, for example by spraying seawater hundreds of meters into the air to seed the formation of stratocumulus clouds over the subtropical ocean.

At the same time some scientists suggest a fairly comprehensive list of reasons why geoengineering might be a bad idea.<sup>32</sup> Though the scientists and ordinary people must more carefully consider geoengineering in their pledge to prevent dangerous anthropogenic interference with the climate system.

### **Energy security**

Global energy security can be defined as a stable system of legal, political and economic relations which allows for a functioning global energy market, manages the negative impact of destabilizing factors in order to ensure reliable supply and demand and a steady supply of energy, maintaining technological and environmental safety.<sup>33</sup> It is clear that climate change is one of the components in the implementation of a strategy aimed at achieving energy security.

Moreover, the problem of climate change is one of the arguments for the increased cooperation between consumers and producers of energy. Firstly, the goals of protecting the environment, as well as the threat of global climate change are the key drivers for the transition of the industry to sustainable production, consumption and resource conservation.

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<sup>30</sup> P. Crutzen " Albedo Enhancement by Stratospheric Sulfur Injection: A Contribution to Solve a policy Dilemma?" (2006) *Climatic Change*, 77: 211–219

<sup>31</sup> T. Wigley "A Combined Mitigation/Geoengineering Approach to Climate Stabilization" (2006) *Science*, v. 314, pp. 452-54

<sup>32</sup> A. Robock "20 reasons why geoengineering may be a bad idea" (2008) *Bulletin of the atomic scientists*, Vol. 64, N. 2, pp. 14-18

<sup>33</sup> 14th Session of the Commission on Sustainable Development (2006) held in New York from 1-12 May

Secondly, it is estimated based on climate models that accelerated in the recent decades global warming would result in the increased access to oil fields, whose development was complicated. It is possible now because of the improved technology and availability of the investment capital. In this regard risks distribution on the large-scale projects between countries would guarantee profit for both sides. It becomes apparent as the irreversible climate change increases competition between rivals for the newly available resources.

Thirdly, the implementation of development projects, such as nuclear energy or conservation technology can significantly reduce greenhouse gas emissions but requires substantial financial investment and the exchange of the advanced technologies; it is not possible without the joint ventures between countries. Thus, energy security, achieved thanks to cooperation between consumers and producers of the energy is a complex task that requires urgent solutions. It is no coincidence that the head of the European Commission in Russia M. Franco said at a joint meeting of working groups on energy efficiency and climate change in Moscow in February 2008: "Issues of climate change and energy efficiency ensure global energy security, which were recognize as one of the key G8 priorities in the areas of bilateral cooperation between Russia and the European Union."

**In conclusion, I would like to quote the words of Mr. P. Hardeker who is a member of the Royal Meteorological Society of Great Britain. Hardeker vividly described the debate on approach to climate change amongst the experts: "We should stick to purely scientific discoveries instead of introducing sensationalism for media visibility and publicity."**