THEORY OF CLIMATE CHANGE INTENSITY DETERMINATION

B.B. Alikhanov[1], S.V. Samoylov[2], V.I. Sokolov[3]

Nowadays Climate Change on the Earth is a fact of life. The main cause of climate change (warming), the impact of which is observed everywhere, it is the growth of concentrations of greenhouse gases (GHG) in the atmosphere.

It is well known that increased emissions of carbon dioxide and methane and other GHG and pollutants, HCFC in the atmosphere mainly caused by human activity, which has and affected changes in the temperature regime of the atmosphere. This, in turn, has affected changes in the circulation and temperature of air masses not only in the lower atmosphere and the destruction of stratospheric ozone, but also changes in the temperature and circulation of water masses in the oceans.

Research related to advancing our understanding of the multiscale dynamic interactions between natural and social systems that influence climate is being conducted by the World Climate Research Program (https://www.wcrp-climate.org).

This program has shown that in the mid-20th century, circulation of the South Ocean, the main absorber for excess atmospheric heat has been changed. This process is due to fact that carbon dioxide is absorbed by cold water of the Ocean, sinks to a depth and is permanently removed from atmosphere. However, this circulation has been disrupted: the wind regime near Antarctica has changed, waters of the Antarctic floor have heated up, and the absorption of atmospheric heat has weakened remarkably. This led to increased cloudiness over the Southern Ocean, which also began to retain heat, and as a consequence to an additional warming of the climate as a whole on the entire planet.

Within framework of the mentioned Program Coupled Model Intercomparison Project (CMIP) is implemented for many years by the Intergovernmental Panel on Climate Change. Presently, the sixth phase of this project is underway, which has presented a forecast, according to which warming by 1,5 degrees Celsius relative to the pre-industrial period is inevitable and will occur in the nearest decades. At the same time, the process of temperature rise leading to climate change will most affect middle and high latitudes of the northern hemisphere of the Earth.

The specifics of atmospheric circulation over Central Asia are due to its location in center of the vast Eurasian continent.

---

[1] Boriy Alikhanov – Senator, Chairman of the Uzbekistan Senate's Committee on the Aral Sea Issues and Environment

[2] Sergey Samoylov – Member of the Expert group under the Uzbekistan Senate's Committee on the Aral Sea Issues and Environment

[3] Vadim Sokolov – Head of Agency of IFAS, Member of the Expert group under the Uzbekistan Senate's Committee on the Aral Sea Issues and Environment

It is known that circulation processes in the atmosphere are mainly influenced by solar energy. Moreover, this energy affects different parts of the planet in different ways due to heterogeneity of the underlying surface, so there is a difference in temperatures on the Earth. Hence, it is clear that intensity of climatic changes will also be different in different regions.

How does air circulate? Cold air, which has a high density, creates a higher pressure and always tends to move into a warmer region with thinner air. As it moves from one area to another, the air mass changes its properties. This depends on what area it passes over, what air masses it borders with, and how much time has passed since it was formed. Usually the transformation of the properties of the air mass lasts from three to seven days - until, as it moves, a constant average daily temperature is established.

Based on this prediction, it is important today to learn how to assess the intensity of climate change in order to properly develop strategies and plans to adapt to these changes and minimize their negative consequences.

Uzbekistan is among the countries most vulnerable to climate change.

Since early 1950s, the average temperature increase on the territory of Uzbekistan was 0,27 0C per decade, which is almost twice as high as the global warming rate. Increase of average annual air temperatures in Uzbekistan occurs against the background of natural variability, which causes significant inter-annual fluctuations.

At the same time, due to the Aral Sea catastrophe, climatic changes are even faster and harsher. A specific feature of the Aral Sea region climate was high frequency and significant duration of dust storms and snowstorms. In general, it should be noted that the territory of Uzbekistan is getting hotter and drier from year to year.

So, according to data of the World Meteorological Organization of the United Nations in 2022, the highest temperature (44 degrees Celsius) in the world was fixed in Uzbekistan (on two observation sites in Navoi Region).

Until mid-1960s, the Aral Sea, having a significant water surface (about 68,900 km2) and a water volume of about 1080 km3, served as a climatic regulating body and mitigated abrupt weather fluctuations in the Central Asian region. The air masses intruding mainly from the west into the region were warmed in winter and cooled over the Aral Sea in summer.

Due to this temperature regime, moistness transported by air currents fell in the form of precipitation over the Tien Shan and Pamir mountains in the autumn-winter period, replenishing snow reserves and the volume of glaciers.

Due to ecological catastrophe of the Aral Sea in last 30-40 years the system of air and moistness circulation on the territory of Central Asia has changed radically.

In winter, air masses come here from the west and north, i.e. initially humid oceanic air from the Atlantic and Arctic zones. On their way across the continent to the territory of the Aral Sea basin, the air masses lose most of their moistness. Here in winter a zone of high pressure is formed due to cooling of the territory (especially after the disappearance of the Aral Sea) and the highland systems of Tien Shan and Pamir along the perimeter of the region. (See Fig.1)

Owing to the drying up of the Aral Sea, climatic changes in the sea basin are much harsher than in other regions, twice as intensive as average values in the world (0,29°C against 0,14°C).

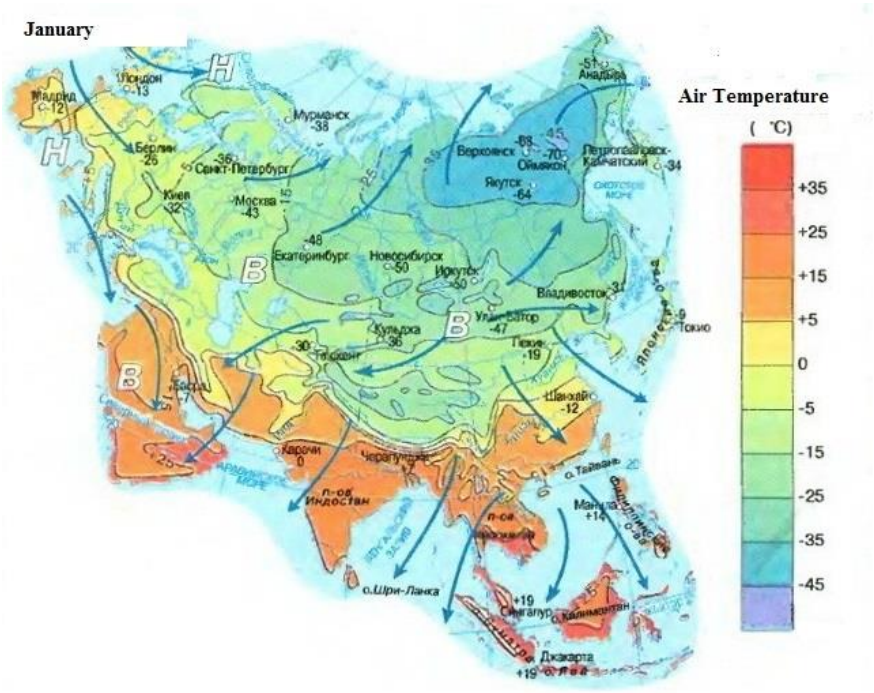

Fig.1. Air and moistness circulation in Central Asia in winter

Thus, we see here in winter formation of the largest high pressure area on the planet - **quasi-stationary Asian maximum**. Due to anticyclonic processes and strong supercooling in the interior of the continent we have observed over the last 20 years that very little precipitation and low temperatures (down to -300C) fall in our region in winter. Moreover, precipitation falls in the flat part, in the mountains it has become less, which affects the reserves of centuries-old snow and glaciers.

In summer, meteorological conditions in the Aral Sea basin change significantly. Due to warming of the territory, the Asian maximum is replaced by an area of low pressure.

Having reached Central Asia, bounded by Tien Shan and Pamir mountains, in summer the incoming oceanic air becomes dry and hot (the Aral Sea as before does not moisten it), the average July temperature here over past 20 years was up to 30 ° C with peaks up to 45 ° C. (See. Fig.2)

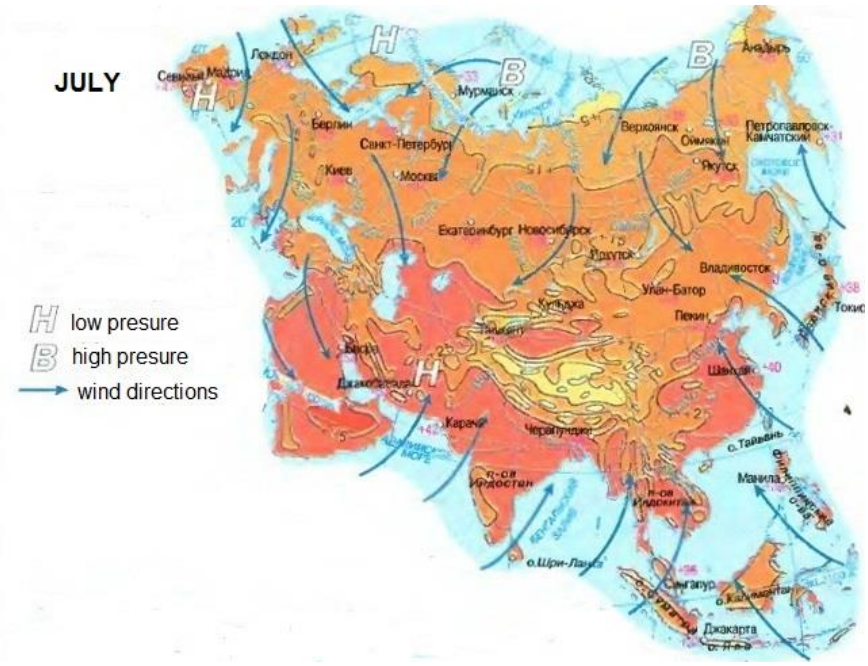

Fig.2. Air and moistness circulation in Central Asia in summer

As a result, we can see decrease of summer precipitation and increased aridization (See fig.3) over the last 25 years. The most dangerous result is intensive melting of glaciers (there are currently 46 glaciers in the region - a loss of up to 30% in 40 years).

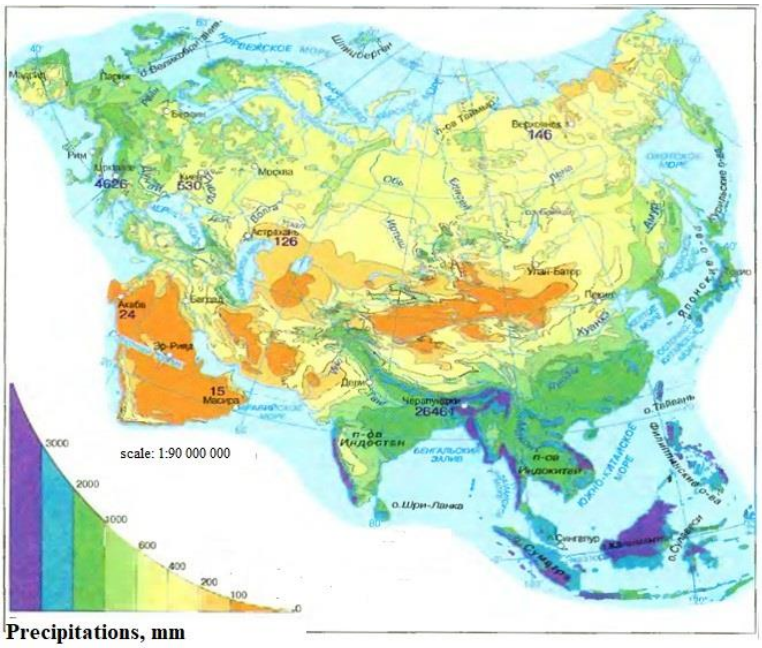

Figure 3. The process of aridization of the territory of Central Asia

(http://worldofschool.ru/geografiya/stati/materiki/evraziya/klimat/obshhie-osobennosti-klimata-evrazii).

In the past, the Aral Sea was a climate-regulating body of water, mitigating abrupt fluctuations of weather in the region, favorably influencing the living conditions of the population, agricultural production and the environmental situation.

Nowadays, the integrity of the region's aquatic ecosystem has already been disturbed - the Aral Sea (the end and integral part of this system) has dried up, and the new desert "Aralkum" of more than 5.5 million ha in its place has a negative impact on the stability of the entire aquatic system. Also degradation of the upper part of the region's water system takes place - glaciers, which provide the main share in water resources formation, are melting. If the process of glacier degradation becomes irreversible - the region will lose hope for stabilization of the whole water system. All efforts made so far in the region to stabilize the Aral Sea area will prove futile. Desertification processes will intensify everywhere in all zones of the region. Risks to socio-economic and environmental well-being will become uncontrollable.

On the whole, climate change has a very significant impact on the environment and human life. First, it shifts the seasons of the year; second, it breaks the cyclicity of precipitation; third, it changes the landscape of the land and causes desertification or waterlogging; fourth, it negatively affects some sectors of the economy (for example, agriculture, water-intensive production, etc.); fifth, it increases water withdrawal and consumption, increases evaporation, including through plant transpiration; sixth, it leads to climate migration, and so on.

Thus, the main goal of joint actions is to find solutions and implement them in order to stabilize the aquatic ecosystem of the region. Innovative approaches are needed to stabilize glaciers and upper catchment ecosystems, increase water resources, improve efficiency of their use, further stabilize the Aral Sea area, stop desertification and reduce the impact of droughts. All this will be the basis for elimination of risks for socio-economic development of the region. However, in order to work out the right way it is necessary to properly assess the intensity of climate change.

It is suggested that intensity of climate change in a particular region (Ji) should be determined by the following formula:

$$\mathbf{J_i = \sum_{t=10} (T \times V) \times R \times G \times K_к \times K_c \times K_{пг}}$$

Where:

T - annual measurement of surface air temperature (or surface temperature?) - seasonal average (at least for ten years t=10 years);

V - atmospheric air humidity;

R - prevailing wind direction (wind mode). Since the inflow from the west and north (North-West) occurs most of the year, it is suggested to take Rnw = 0.7 (cold season), and southwest index Rsw = 0.3;

G – Geographic location of the region (tropical, equatorial, temperate, polar). Based on the CMIP forecast, which says that the highest intensity will be in the temperate belt and the polar belt - the following coefficients are proposed for these regions: G temperate belt = 2, G polar belt = 1.5. For the tropical and equatorial belt, the index is 1.25. This approach to estimating the geographical coefficient is related to the response of radiation reflected from clouds. Total radiation is the total influx of solar radiation to the horizontal surface of the Earth. Annual amounts of radiation influx vary from 40 kcal near the polar circle to 100 kcal in the Mediterranean and Central Asia;

$\mathbf{K_к}$ – is a correlation index that takes into account the specificity of the territory (urbanized K = 2, rural area K = 1.7, forests K = 1.0, desert K = 1.5, etc.);

Кс – cyclist index, which characterizes the number of recurrences of: floods; droughts; fires; abnormal natural phenomena (downpours, tornadoes, volcanic eruptions, dust storms, etc.);

Кnr – index of reduction (loss) of natural resources, characterizes the number of lost types of resources (flora and fauna, water resources and other types of natural resources).

Where and how we are going to practically apply this formula?

In response to losses caused by the agricultural droughts occurred in Uzbekistan during last 20 years, the Global Water Partnership (GWP) expressed its readiness to provide technical and methodological support for preparation national plan to combat drought in Uzbekistan. This support is funded by the US National Oceanic and Atmospheric Administration.

From December 2021 to March 2022, with involvement of national experts, an Overview of the current state of drought management in Uzbekistan, as well as concept of the National Drought Management Plan, was prepared. The goal of National plan is to address drought-related issues through monitoring and early warning, vulnerability and risk assessment, and drought mitigation and adaptation measures.

On April 5, 2022, a workshop was held in Tashkent to discuss the necessary steps to develop a National Drought Management Plan 2023-2030. The workshop was attended by representatives of all ministries, departments, research institutes, non-governmental organizations involved in the problem of droughts.

As a result, recommendations were given on the content of the national plan, namely:

- The first priority area is capacity development for monitoring, risk assessment and drought prevention: strengthening the technical base of the Hydrometeorological Service and introducing innovative solutions for drought monitoring and forecasting; development of a drought monitoring and early warning system that will improve the decision-making process for planning and managing risks regarding the impact of drought on food and water security.
- The second priority is drought mitigation. This includes the development of measures to address water scarcity issues based on monitoring and early warning data: the degree of expected low water and drought (a set of indicators) is a criterion for the adoption of certain action plans to mitigate the effects of the expected drought.
- The third priority area is capacity building and awareness rising: it is important to raise the awareness of the rural population (including women) about climate change adaptation and effective agricultural practices.
- The fourth priority area is to actively develop regional cooperation: given the transboundary nature of the effects of drought, cooperation between the countries of the region is extremely important. In this regard, participants turned to the Global Water Partnership to provide all possible assistance in activating regional and international cooperation on drought risk reduction.

Thus, proper assessment of the climate change intensity is valuable contribution to the more strict formulation of the National Drought Management Plan.