DYNAMICS OF THE GLOBAL ATMOSPHERIC CIRCULATION AND THE CLIMATE CHANGE

Nina K. Kononova, Institute of Geography, Russian Academy of Sciences

NinaKononova@yandex.ru

www.atmospheric-circulation.ru

Fluctuations in the global atmospheric circulation in 1899-2017, in the classification by BL Dzerdzeevskii considered. Three circulation epochs identified. Frequency elementary circulation mechanisms (ECM) in each epoch analyzed.

Long-term fluctuations in mean annual air temperature in Northern and Southern hemispheres and the global and also the annual amplitude of air temperature due to changes in the nature of atmospheric circulation are analyzed.

Particular attention is paid to the last period (1998-2017). During this period, in the lower troposphere maximum meridional transport of air masses is observed (on average 335 days per year). In 93 days on average per year macroprocesses with cyclones at the poles, without blocking processes, with three or four cyclones outputs from low to high latitudes in each hemisphere observed (type 13). On other days macroprocesses with anticyclones at the poles, the outputs of the cyclone from low to high latitudes in two-four quadrants of each hemisphere and the Arctic/Antarctic invasions in their rear, forming a blocking process (types 8 to 12) are marked. As a result, the average annual air temperature in the Northern, Southern Hemispheres and the global ceased to rise each year as in 1981-1997. Although 2016 proved to be the warmest on Earth since 1850.

Due to the growth of the length of the high pressure in winter and summer annual amplitude of air temperature for the present time is growing. Because of the high pressure over Eurasia winter Atlantic cyclones go to the Arctic, ice in the Kara and Barents Seas decreases. Simultaneous outputs cyclones in different sectors cause the occurrence of natural hazards in different regions.

From a comparison of the variations in air temperature with the variations in the atmospheric circulation, it can be seen that the air temperature follows a change in the nature of the circulation of the atmosphere. The first epoch (1899 - 1915), the epoch of blocking processes, was the epoch of cooling: the average global air temperature, as well as the average air temperature of the Northern Hemisphere, decreased. The second epoch (1916 - 1956) is zonal, it became the epoch of the first global warming in the XX century, which went down in history as the warming of the Arctic. The third epoch (1957-present time), the epoch of cyclone outflows from low latitudes to high, in contrast to the first two, breaks up into periods. 1957 - 1969 characterized by an increase in the duration of blocking processes, which led to a decrease in air temperature.

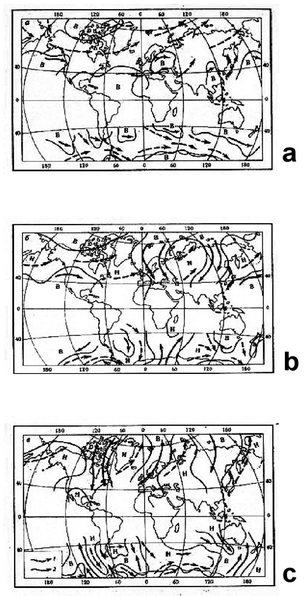

Fig. 1. Comparison of standard schemes of atmospheric circulation over the Northern and Southern hemispheres (Northern - by BL Dzerdzeevskii [1], Southern – by PD Astapenko): a - zonal circulation, b - two meridional blocking processes in each hemisphere, c - three meridional blocking processes in each hemisphere. Dotted arrows - generalized path of cyclones, solid — anticyclones.

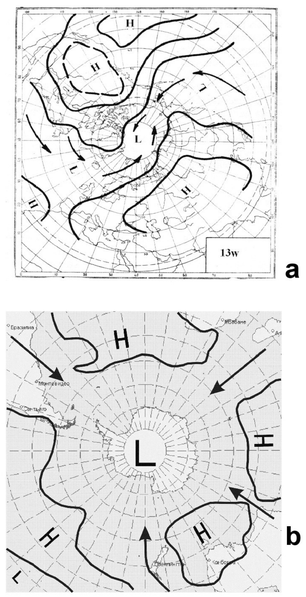

Fig. 2. Dynamic schemes of ECM 13w (for the Northern Hemisphere winter): a - Northern Hemisphere (by BL Dzerdzeevskii [1]), b - the Southern Hemisphere.

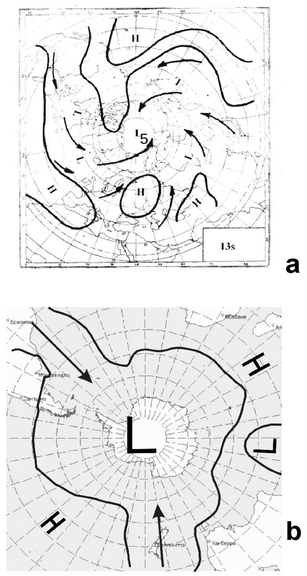

Fig. 3. Dynamic schemes of ECM 13s (summer in the Northern Hemisphere): a - Northern Hemisphere (by BL Dzerdzeevskii) b - the Southern Hemisphere.

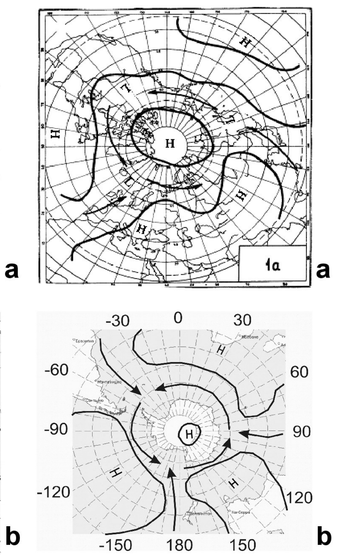

Fig. 4. Dynamic schemes of ECM 1a (zonal circulation, for the Northern Hemisphere winter): a - Northern Hemisphere (by BL Dzerdzeevskii [1]), b - the Southern Hemisphere.

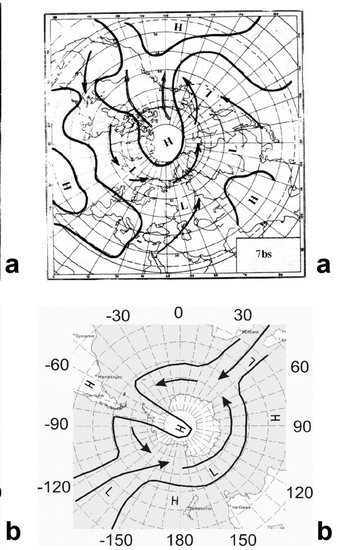

Fig. 5. Dynamic schemes of ECM 7bs (disturbance of zonal circulation, summer in the Northern Hemisphere): a - Northern Hemisphere (by BL Dzerdzeevskii) b - the Southern Hemisphere.

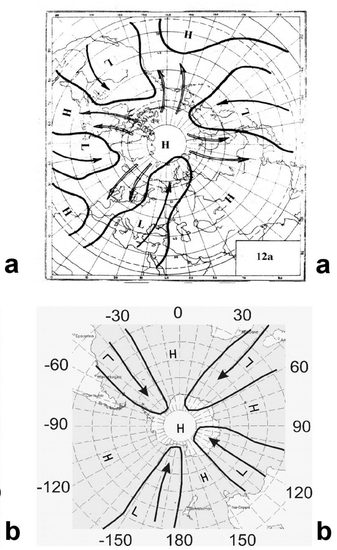

Fig. 6. Dynamic schemes of ECM 12a (group blocking processes, transitional seasons): a - Northern Hemisphere (by BL Dzerdzeevskii [1]), b - the Southern Hemisphere.

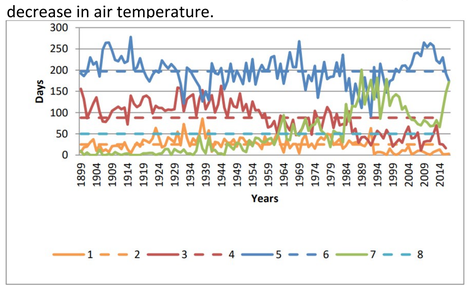

Fig. 7. Duration of circulation groups for 1899-2017 : 1 - zonal, 2 - zonal average, 3 - disturbance of zonal, 4 - - disturbance of zonal average, 5 - blocking processes, 6 - - blocking processes average, 7 – cyclones on the poles and cyclone outlets from low to high latitudes, 8 - cyclones on the poles and cyclone outlets from low to high latitudes average.

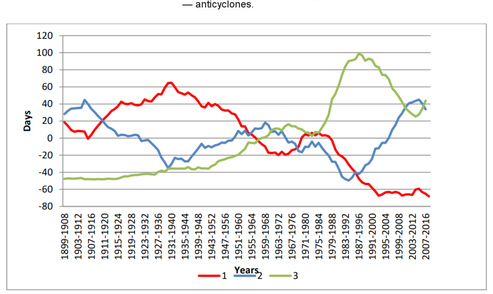

Fig. 8. 10-year smoothed average deviations in the duration of circulation groups from their average for 1899-2017. 1 - zonal + Disturbance of Zonal, 2 - group of blocking processes, 3 - group of cyclone outlets from low latitudes to high ones

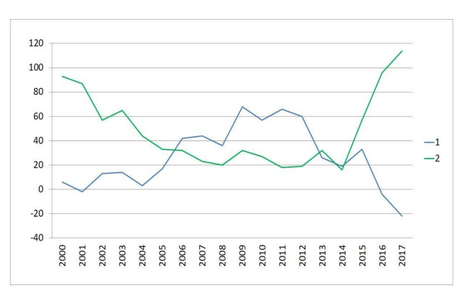

Fig. 9. Deviations of the group of blocking processes (1) and cyclone outlets from low latitudes to high (2) in the 21st century. from their average for 1899-2017.

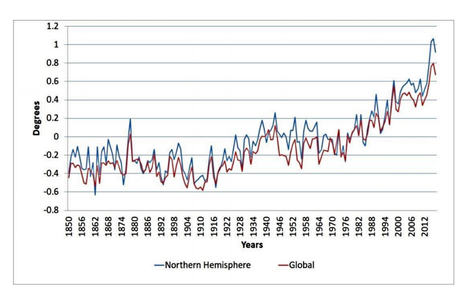

Fig. 10. Deviations of the average annual air temperature for the years 1850 - 2017 from the average for 1961-1990.

In the period 1970 - 1980, the duration of zonal circulation increased. In addition, during this period the duration of all groups was close to the average. It can be assumed that the dynamic schemes built between 1970 and 1978, best reflect the average position of cyclones and anticyclones at each ECM. Between 1981 and 1997, the duration of the cyclone outflows from low latitudes to high was rapidly increased. The air temperature also increased rapidly, reaching a maximum in 1998. Since this year, the duration of the cyclonic circulation group has begun to decrease, and the groups of blocking processes have increased. However, now the group of blocking processes is growing mainly due to the ECM with four blocking processes and four cyclone outlets from low latitudes, so that the number of cyclone outlets, especially in summer, has not changed, so the temperature did not decrease, but fluctuated at the highest level up to 2015, when due to the increase in the duration of cyclone outcrops from low latitudes, it again increased.

Meteorological extremes and natural disasters

The most terrible natural disasters in Russia are droughts, natural fires, severe frosts and floods. The decade of 1931-1940. differed from the subsequent by almost annual strong and extensive droughts and minimum average humidification of the territory. By the nature of the circulation of the atmosphere, this was the peak of the zonal epoch, when on the Eurasian continent there were anticyclones in winter and summer, and Atlantic cyclones were forced to bypass them along the northern coast of Eurasia, facilitating navigation along the Northern Sea Route. The air temperature in the central regions of European Russia and in the Lower Volga region in the winter of 1938-1942. fell below -40^{0}C. Deficiency of rainfall is also reflected in the life of glaciers.

In the 21st century, the change in the nature of the circulation of the atmosphere generates outstanding extremes: an unprecedented drought and natural fires in European Russia in 2010, a severe flood in the Novorossiysk area in 2002, a catastrophic flood in the city of Krymsk in 2012, a catastrophic flood in Primorye in 2013. In May 2014, in the Altai Territory due to heavy precipitation and melting of glaciers, the Ob flowed with tributaries, 33,000 inhabitants, 4,000 houses, bridges, roads were damaged.

With the current nature of atmospheric circulation (4 simultaneous cyclone outputs from low latitudes with the most common ECMs 12a and 13s), simultaneous extreme events associated with severe precipitation in different parts of the hemispheres are not uncommon. So, on May 28, 2014, rains in the Stavropol region, because of which the emergency regime was introduced, took place simultaneously with downpours in the Altai and in China.

Conclusion

Create dynamic diagrams ECM Southern Hemisphere allows us to analyze the global circulation of the atmosphere.

In the development of the global atmospheric circulation in the 1899-2014 marked three circulation epoch: blocking processes, zonal and outputs cyclones from low to high latitudes differing prevalence of certain macro-processes. Fluctuations in global average surface air temperature correspond to fluctuations of the global atmospheric circulation.

The modern character of the atmospheric circulation caused the increases frequency meteorologically due by natural hazards in different regions of the Earth, including the occurrence of simultaneous disasters ice in the Arctic and Antarctic.

References

1. Dzerdzeevskii BL, Kurganskaya VM and Vitvitskaya ZM 1946. Classification of circulation mechanisms in the Northern Hemisphere and the characteristics of synoptic seasons. *Proceedings of research institutions Hydrometeor. Service under the Council of Ministers of the USSR. Ser.* ***2****. Synoptic meteorology; Issue.* ***21****. Central Institute of Forecasts. M., L., Hydrometizdat, 80 p.*
2. Dzerdzeevskii BL 1967. Comparison of the main regularities of atmospheric circulation over the Northern and Southern hemispheres. *Information Bulletin of the Soviet Antarctic Expedition, No.* ***65****, p.58-68. (BL Dzerdzeevskii, Selected Works, edited by Nauka, 1975, pp. 149-158).*
3. Dzerdzeevskii, B 1962. Fluctuations of Climate and of General Circulation of the Atmosphere in extra-tropical latitudes of the Northern Hemisphere and some problems of dynamic climatology. *TELLUS, XIV, No* ***3*** *pp. 328-336*
4. Climatic Research Unit Data URL: http://www.cru.uea.ac.uk/cru/data/temperature/
5. Weather news, URL: www.meteonovosti.ru
6. Kononova NK 2009. Classification of the circulation mechanisms of the Northern Hemisphere according to BL Dzerdzeevskii. Ed. AB Shmakin; Russian Acad. Sciences, Institute of Geography. - Moscow: Voyentekhinizdat, 372 p.
7. Fluctuations in the atmospheric circulation of the Northern Hemisphere in the XX - early XXI century. URL: http:www.atmospheric-circulation.ru
8. Dzerdzeevskii BL 1956. The problem of fluctuations in the general circulation of the atmosphere and the climate. *Al Voeikov and modern problems of climatology. L .: Gidrometeoizdat, p. 109-122.*

Climate Change: Impacts & Responses