

The scenarios of repeatability of catastrophic climatic phenomena in Europe and Ukraine under the influence of climate changes (with use of historical records and manuscripts for the last millennium)

© *S. Boychenko, 2010*

Institute of Geophysics, National Academy of Sciences of Ukraine, Kiev, Ukraine
uaclimate@gmail.com

The climatic catastrophic phenomena, such as droughts, floods, extremely cold or warm winter, occurring at a large scale and great intensity are rather rare events. These phenomena, typically, occur only a few times per century. Because of this, statistically estimating the basic characteristics of the dynamics of repeatability of these events is very difficult. The instrumental observations are not helpful because of the short time-series. It is therefore necessary to use other proxy data as well. In our opinion, different historical records and manuscripts are most suitable for this purpose. These records were very carefully compiled and described in the monasteries located in territory Europe [Borisenkov, Pasetky, 1988].

The analysis is carried out on the basis of historical records and manuscripts for the last millennium (900—1800) [Borisenkov, Pasetky, 1988]. The following phenomena were considered: droughts, rainy summers, floods, cold winters, late springs, colds at the beginning of a summer, catastrophic thunderstorms and catastrophic storms. It was used the names of these events, which are described in historical records and manuscripts.

The statistical analysis of these data shows that the long-term dynamics of repeatability of the climatic catastrophic phenomena in the territory Europe, Ukraine and Russian Plain was not similar to an ordinary stationary Poisson's flux of events [Boychenko, 2002]. It is supposed by our hypothesis

that the temperature fluctuations in Europe could be as main factor influencing dynamics of repeatability of the phenomena [Voloshchuk, Boychenko, 2001; Boychenko, 2003; 2008]. Namely, the repeatability of the considered events is a non-monotonic function of temperature fluctuations: repeatability of catastrophic climatic phenomena in the territory of Europe was higher, when the temperature of Europe was increased (the Little Climatic Optimum) or, on the contrary, decreased (the Little Ice Age) [Boychenko, 2003; 2008; Voloshchuk, Boychenko, 2001]. Necessary characteristics of anomalies of temperature on Northern hemisphere for last millennium were restored Mann, Crouly etc and time-series for territory of the East Europe of Imbrie etc (quoted by [Boychenko, 2008]).

It is used the theory of similarity. The following basic criteria of the similarity theory of dynamics of frequency of the catastrophic climatic phenomena are worked out: collective rating of group of catastrophic climatic events X ; index of level of climatic anomalies Q ; dimensionless optimum level q of a thermal regime for considered geographical region.

Definitions of these criteria of similarity are formulated and proved and algorithms for calculation of their values are given on the basis of empirical materials or the given different modeling calculations:

$$X(t) = \sum_{k=1}^N \frac{n_k(t) - a_k}{s_k}, \quad Q(t) = \frac{1}{s_T^2} (\Delta T(t) + s_T q)^2,$$

$$\delta t = 50 - 100 \text{ years}, \quad \Pi = \{900 - 1800 \text{ years}\}, \quad (1)$$

where δt — elementary time unit; X — a collective rating of events; $n_k(t)$, a_k and s_k^2 — repeatability for time t , average repeatability during period Π and a dispersion of repeatability during the same period of time k -the events; $\Delta(t)$ — anomalies of annual temperature for the East Europe or Northern hemi-sphere, for a time t ; q — an optimum regional level of temperature which can accept different values for different regions.

Developed semi-empirical model of probability of dynamics of repeatability of the catastrophic climatic phenomena for different physic-geographical regions shows that:

$$\begin{aligned} X(t) &\approx \chi(t) = \beta Q(t) \pm s_\chi, \\ v_k(t) &= [a_k + s_k \chi(t)] \Delta t, \\ P_m(k, t; \Delta t) &= \frac{v_k^m}{m!} e^{-v_k}, \\ \beta &= 0,8 \pm 0,2, \quad s_\chi = 0,6, \end{aligned} \quad (2)$$

where m — amount of occurrences k^{th} events during for time t , P — probability occurrences of k^{th} events for time t , s_χ — a root-mean-square error of a collective rating of events, Δt — interval time in elementary units δt .

It was for the first time established existence excitation effect of the catastrophic climatic phenomena in different regions of Europe to an index of climatic anomaly Q (Fig. 1).

On a basis of the criteria's equation the scenarios of increase of frequency of occurrence of different catastrophic climatic phenomena in territory of Ukraine, East European plain and the Western Europe in 21st century are constructed. Validity of the semi-empirical models are checked up by the decision of a return problem: comparison of results of

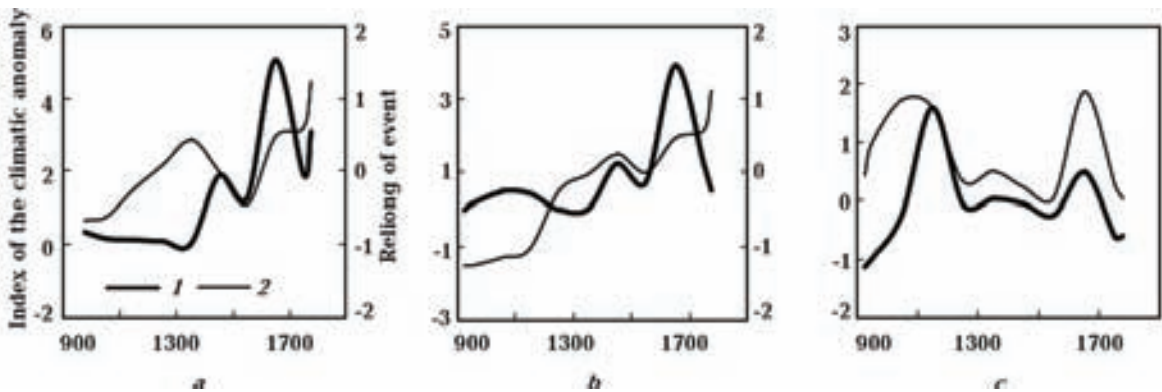


Fig. 1. A century course of an index of the climatic anomaly (1) and a rating of catastrophic climatic events (2) in territories: a — Western Europe, b — Russian plain, c — Ukraine (the rating for Russian plain is displaced for 100 years forward).

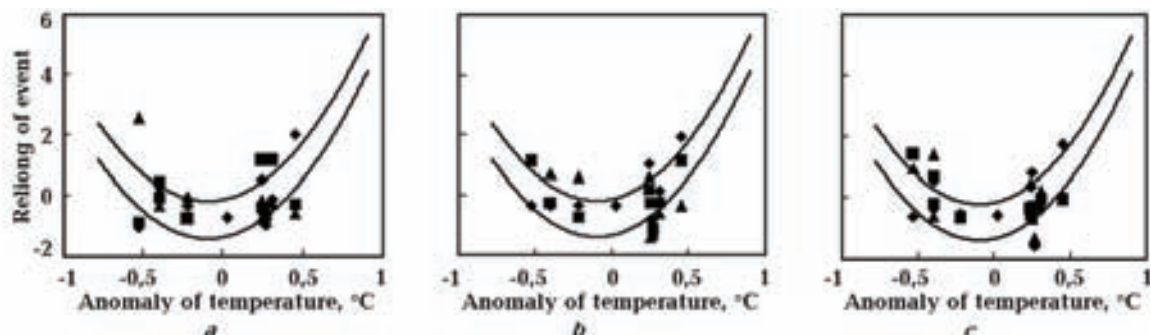


Fig. 2. Scenarios of dynamics of frequency of catastrophic climatic events in territory: *a* — Western Europe, *b* — Russian plain, *c* — Ukraine (droughts, flooding, unknown storms), calculations on ratio formule (1); on an axis OX anomalies of temperature for Northern hemisphere.

modeling calculations with the fact for last millennium (11—13 century). By the developed scenarios it is possible to draw a conclusion, that the expected average amount of the considered catastrophic climatic events in 21st century in territories of Ukraine, the Western Europe and Russian plain in 1.5—2 times will exceed their fixed quantity in 12th century — for epoch of known global warming in the last millennium (Fig. 2).

It is found that the repeatability of the considered events is a non-monotonic function of temperature fluctuations, namely: repeatability of catastrophic climatic phenomena in the territory of Ukraine was

higher, when the global temperature was deviating in either direction from some optimum level (at global warming or cooling from some optimum level of global temperature) [Boychenko, 2002; 2003]. It is established, that this effect takes place also for all Europe. Semi-empirical models for rating of intensity of climatic catastrophic phenomena in Ukraine as function of index of climatic anomaly are constructed. A scenario of possible dynamics of repeatability of climatic catastrophic phenomena in the territory of Ukraine at the further global warming is considered [Voloshchuk, Boychenko, 2001; Boychenko, 2008].

References

- Borisenkov Ye. P., Pasetsky V. M.* The thousand-year annals of extraordinary natural phenomena. — Moscow: Mysl, 1988. — 524 p. (in Russian).
- Boychenko S.* Frequency of catastrophic phenomena in Ukraine under the influence of global warming // Water Resources Systems — Hydrological Risk, Management and Development (Proceedings of symposium HS02b held during IUGG2003 at Sapporo, 2003). — IAHS Publ, 2003. — № 281. — P. 18—25.
- Boychenko S.* Semi-empirical models and scenarios of global and regional changes of climate. — Kiev: Nauk. dumka, 2008. — 310 p. (in Russian).
- Boychenko S.* Semi-empirical statistical models of connection of repeatability of the catastrophic phenomena in Europe with global temperature anomalies in last millennium (on the basis of historical records and annals). Proceedings of Third International Conference on Water Resources and Environment Research (CWRER). — Germany, 2002. — 1. — P. 224—229.
- Voloshchuk V., Boychenko S.* The effect of intense increase in repeatability of catastrophic processes and phenomena in the territory of Ukraine under the conditions of global warming or cooling // Ann. of the National Academy of Sciences of Ukraine. — 2001. — № 5. — P. 105—112 (in Russian).