Multidecadal climate variations:
Assessment of their influence on temperature trends

Igor I. Mokhov and Vyacheslav A. Bezverkhny

A.M. Obukhov Institute of Atmospheric Physics RAS
mokhov@ifaran.ru

General warming during the last century is accompanied by remarkable quasi-cyclic natural climate variations with a significant role of multidecadal variations with a period of about 6 decades. The analysis of surface air temperature (SAT) observations in the 19th century shows the key role of atmospheric CO_2 in the centennial global climate changes [1-4]. According to [1], more than 3/4 of the global SAT variance is due to CO_2. The natural 60-year mode and all the remaining factors are responsible for 1/20 and 1/6 of the global SAT variance, respectively. For the Arctic, the appropriate CO_2 contribution is assessed at less than 1/2, while that of the 60-year mode is about 1/6. The contribution of variations in solar radiation ("solar activity") was estimated as insignificant (less than 1%).

What is the quantitative influence of the natural 60-year mode on the contemporary SAT trends? Figure 1 shows an example of extrapolation of SAT variations in the Northern Hemisphere (NH) from the GISS data (http://data.giss.nasa.gov/gistemp/) up to the 22nd century. Similar estimates can be made for the Arctic with the most rapid climate changes [4].

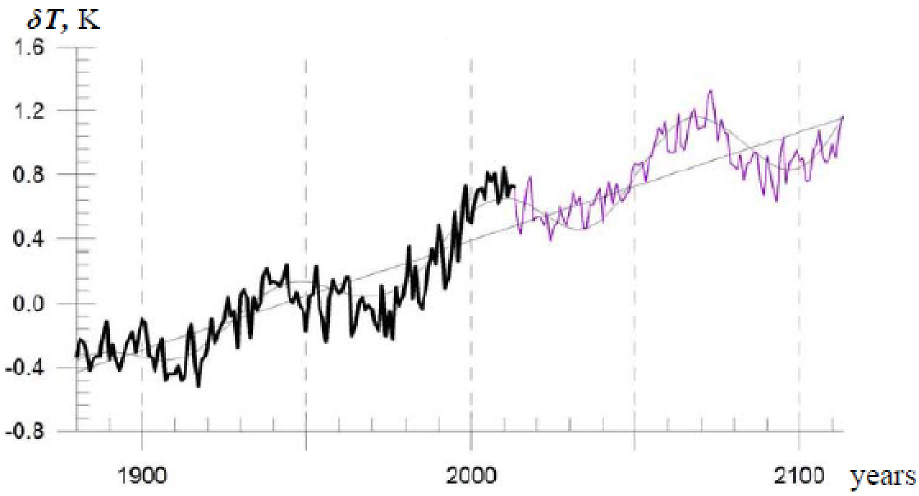

Figure 1. Extrapolation of SAT variations in the Northern Hemisphere from the GISS data (black curve) up to the 22nd century (violet curve). Variations around the linear trend line which characterize the 60-year mode are shown in grey.

Taking into account the current phase of the 60-year mode against the background of the centennial warming, a slowdown of warming or even a local cooling should be expected in the next two decades, followed by the amplification of warming at regional and global scales. Let us consider the simplest case of SAT ($T(t)$) harmonic oscillation with the period T_0 (60 years) and the amplitude ΔT against the background of the centennial SAT trend $(dT/dt)_c$:

$$T(t) = T_c + (dT/dt)_c t + \Delta T sin(2\pi t/T_0 + \varphi_0). \qquad (1)$$

According to (1), the maximum and minimum SAT trends are

$$(dT/dt)_{max} = (dT/dt)_c + 2\pi(\Delta T/T_0)$$

and

$$(dT/dt)_{min} = (dT/dt)_c - 2\pi(\Delta T/T_0),$$

respectively. In such a case, the necessary and sufficient condition for the absence of a time interval with cooling is as follows [4]:

$$\left(\frac{dT}{dt}\right)_c / \left(\frac{2\pi\Delta T}{T_0}\right) \geq 1. \qquad (2)$$

For the whole Arctic, the amplitude of the multidecadal climate oscillations with a period of about 60 years can be estimated at about 0.3 K (with a maximum in the first decade of the 21st century) with the uncertainty ranging from 0.2 K to 0.4 K . The centennial SAT trend in the Arctic $(dT/dt)_A$ was estimated at 2.4 K/(100 years). For the validity of (2), the amplitude $(\Delta T)_A$ of SAT oscillations with a 60-year period T_0 in the Arctic should not exceed $(dT/dt)_A$ $(T_0/2\pi)$=0.23 K [4].

In the Northern Hemisphere the corresponding amplitude of SAT oscillations with a period of about 60 years (with a peak in the first decade of the 21st century) is about 0.2 K (with a minimum at about 0.1 K). The centennial NH SAT trend $(dT/dt)_{NH}$ was estimated at 1.0 K/(100 years). For the validity of (2), the amplitude $(\Delta T)_{NH}$ of the NH SAT oscillations with a period T_0 of about 60 years should not exceed $(dT/dt)_A$ $(T_0/2\pi)$=0.1 K [4].

According to the estimates, we should expect not only the hiatus effects in the global warming but also temporary cooling during the next two decades.

References

1. IPCC (2013): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. T.F. Stocker, D. Qin, G.-K. Plattner et al. (eds.). Cambridge Univ. Press, Cambridge / N.Y., 1535 p.
2. Gruza G.V., Rankova E.Y. (2012) Observed and Expected Climate Changes in Russia: Air Temperature. VNIIGMI MTsD, Obninsk, 194 p.(in Russian)
3. Mokhov I.I., Smirnov D.A., Karpenko A.A. (2012). Assessments of the correlation between variations in the global surface air temperature and different natural and anthropogenic factors based on the data of observations. *Doklady Earth Sci.,* **443**(1), 381-387.
4. Mokhov I.I. (2015) Contemporary climate changes in the Arctic. *Herald of the Russian Academy of Sciences,* **85**(3).